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REPORT

FROM

THE SECRETARY OF WAR,

IN COMPLIANCE

With a resolution of the Senate of the 24th January, 1838, with a report of the survey of the Charleston and Cincinnati railroad.

FEBRUARY 2, 1838.

Read, and ordered to be printed, and that 500 additional copies be furnished for the use of the Senate.

DEPARTMENT OF WAR,
February 1, 1838.

SIR: The report of the survey of the Charleston and Cincinnati railroad, called for by a resolution of the 24th ultimo, is herewith respectfully transmitted.

Very respectfully,
Your most obedient servant,
J. R. POINSETT.

Hon. R. M. JOHNSON,
President of the Senate.

TOPOGRAPHICAL BUREAU,
Washington, February 1, 1838.

SIR: I have the honor to submit to you a copy of the report of the chief and associate engineer of the Charleston and Cincinnati railroad, called for by a resolution of the Senate of the 24th ultimo.

Very respectfully, sir,
Your obedient servant,
J. J. ABERT,

Lieut. Col. Topographical Engineers.

Hon. J. R. POINSETT,
Secretary of War.

Blair & Rives, printers.

Joint report of the chief and associate engineers of the Louisville, Cincinnati, and Charleston railroad.

ENGINEER OFFICE, L. C. & C. R. C.,
Flat Rock, N. C., Oct. 7, 1837.

SIR : The period prior to the proposed meeting of the board of directors, on the 9th instant, preparatory to that of the stockholders on the 16th, being about to expire, we dispense with the plea which will naturally suggest itself, and which, in justice to ourselves and the subject, might with propriety be urged, of the want of time ordinarily allowed to present fully the facts disclosed by such extensive operations as those in which we have been occupied during the past season, between the city of Charleston and the Ohio river; and, in the emergency of the occasion, hasten to embody such results as in so very limited a time we can now collate, and which we respectfully submit in the following report.

The operations extending over so large an extent of territory, have not been (nor could they by any one expected to have been) so minute, in all other modifications, as to enable us to locate with precision, and estimate with accuracy, the relative cost of the work on each or any of the proposed routes. Enough, however, has been disclosed to determine beyond the shadow of doubt, not only the great feasibility of the project, but the far greater facility with which the passage of the Alleghany mountains may be effected by the routes within the limits of our recent surveys, than in any other section of the United States with which we are acquainted; and, in years past, we have been called on minutely to survey this mountain region, even from the heads of the Susquehannah and Potomac rivers in Pennsylvania, to those of the Roanoke river in Virginia; in which we were almost continually occupied during an entire period of four years. We may be supposed, therefore, to have had ample time to become familiar with this part of our subject; and of our own knowledge, corroborated by the official statements of others, including several of the ablest engineers, who have since been similarly occupied, it is by no means difficult to prove the fact of superiority which we claim for the route of a railroad, connecting the eastern and western waters, flowing in opposite directions *through the Carolinas*, over all others. It will, in the sequel, be seen, that it is not only distinguished by the great ease with which it enables us, from the eastern or southern base of the great chain of mountains, (below which, to its termination at the city of Charleston, we all know the favorable character of the country,) so to distribute the ascent as gradually to attain the very summit of the Alleghany, or Blue ridge, at inclinations far within the limit of the advantageous application of locomotive engines, (and, of course, without the intervention of a single *incline* requiring stationary power;) but it is peculiarly so, by the extraordinary facility with which the descent westward is effected, from the summit of what, in all other similar projects, is considered the almost insurmountable barrier—the GREAT ALLEGHANY RANGE—which fact we think cannot too strongly be impressed. For already, by either route which might be adopted—whether we pass the Butt Mountain gap, or the Reedy Patch gap—imperceptibly we shall have reached the valley of the French Broad river, which,

rising, as it were, on the very summit of the Alleghanies, gently (more gently than any mountain stream in these United States)—although it may be said literally to break through the numerous mountains which here form the Alleghany range—permits us to descend, almost uninterruptedly throughout its course, for the distance of 145 miles, or even to the city of Knoxville.

But not to anticipate unnecessarily—we shall no further enlarge at this stage of our report, on this interesting topic, than by presenting a few leading facts in substantiation of our statements. Confining ourselves to the main railroad avenues which have been constructed, or projected, across the mountains, it will be seen by the following tabular statements,* that in *extent of mountain construction*, in *elevation of the mountain*, in *gradients*, both *ascending and descending*, in fine in all its essential features, our route through the Carolinas has the decided advantage over those with which we have placed it in contrast; nor is there any other similar railroad projected, that we are aware of, with which we could have compared it,

* *STATEMENT of distances, grades, and heights, overcome by the Pennsylvania railroad, Baltimore and Ohio railroad, and Louisville, Cincinnati, and Charleston railroad, in their passage across the Alleghany mountains.*

Railroads.	Length of line across the mountains.	Elevation of highest point above base.	Total ascents going westward.	Total ascents going eastward.	Total heights overcome.	Heights overcome by inclined planes.	Length of inclined planes.
	<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Miles.</i>
Baltimore and Ohio railroad -	63.71	1,731	1,681	1,042	2,723		
Pennsylvania portage railway -	36.45	1,398	1,398	1,173	2,571	2,007	4.39
Louisville, Cincinnati, and Charleston railroad -	24.36	1,054	1,054	-	1,054		

Grades for motive power.

Railroads.	Level.	25 feet per mile, and under.	40 feet per mile.	60 feet per mile.	50 feet per mile, and over 25.	75 feet per mile, and over 50.	92 feet per mile, and over 75.
	<i>Miles.</i>	<i>Miles.</i>	<i>Miles.</i>	<i>Miles.</i>	<i>Miles.</i>	<i>Miles.</i>	<i>Miles.</i>
Baltimore and Ohio railroad -	-	26.71	-	-	7.05	3.00	16.05
Pennsylvania portage railway -	0.15	28.19	3.72	-	-	-	-
Louisville, Cincinnati, and Charleston railroad -	5.16	2.00	2.40	14.80	-	-	-

† N. B.—There is every reason to believe that this grade of 60 feet to the mile, for 14-810 miles, can be reduced to within a limit of 50 feet to the mile.

save one which is sometime proposed to connect the James or the Roanoke rivers, with the Great Kenawha, which we *especially* know (for it for two years claimed our attention) cannot come into favorable competition. On this point, however, we think the remarks of the United States Board of Engineers consisting of Gen. Bernard, Capt. Poussin, and our lamented friend, Dr. Wm. Howard, on a report on their examination of the country for the Ohio and Chesapeake canal, or rather on a general examination of the Alleghany mountains, may not inappropriately be introduced. After developing the immense resources of the western States, and the necessity of their having numerous communications with the sea, they remark: "These States will, therefore, require a certain number of outlets to facilitate the exportation of all these products, and the importation of the returns; and it is doubtful if even four of these outlets will be found practicable between the Juniatta and the Savannah rivers, even by the combination of *canals and railroads*. Thus, instead of fearing that these communications will not be profitable, we should rather apprehend that, at a future day, they will be found insufficient for the passage of the trade between the west and the east. The insurmountable obstacles opposed by nature, are thus the only ones which should limit our efforts; for the more economical outlets we can open through this chain, the more will the resources of the west develop themselves, and the more will the east and the west become united in indissoluble bonds of a common interest." But much that we would say must be postponed for the present, or communicated verbally, till, under less pressing circumstances, we can enlarge on the subject of this communication.

In conformity, too, with our usual plan, we would have been glad to enter into a description of the geological character of the country, and indeed its physical resources under every aspect. The more so, that the trace of our surveys from one extremity to the other, is singularly characterized by its advantages; not one point of our line throughout its trans- itions is without interest of a striking character in some feature highly advantageous to the project. Time, however, does not permit us to dwell upon detail, and a cursory glance of these peculiarities is all we are at present enabled to give.

The following table shows the length, grades, and amount of descents overcome in the passage on the western slope of the Alleghany mountains, in the abovementioned works.

Railroads.	Length of inclined planes.	Descent by inclined planes.	Length overcome by motive power.	Whole descent by motive power.	Whole length of descent.	Whole descent.	Average grade per mile.
	Miles.	Feet.	Miles.	Feet.	Miles.	Feet.	Feet.
Baltimore and Ohio railroad	-	-	43.71	1,042	43.71	1,042	23.84
Pennsylvania portage railway	1.83	802	23.70	370	26.53	1,172	44.21
Louisville, Cincinnati, and Charleston railroad	-	-	7.00	95	7.00	95	13.57

It will be perceived, that our lines of survey and reconnoissance comprised an extent of territory stretching from south-southeast to north-north-west, on a distance of about 700 miles, and although circumstances have not permitted us to operate upon the whole of this extended line instrumentally, yet a continuous line from Columbia to Lexington, with various modifications, has been completed, which, in point of length, has far exceeded that distance. These investigations have been conducted through every diversity of soil and climate, traversing regions rich in mineral wealth, and fertile territories that have been hitherto entirely shut out from commercial intercourse with every mart of commerce that could serve as an outlet to their pent up agricultural resources. Traversing the finely timbered lands of South Carolina, the line intersects the iron region at the foot of the mountains, through the very heart of a district where numerous works for the manufacture of that valuable auxiliary to our enterprise are already established. Following one of the lines which may be adopted, it intersects the White Oak mountain, at the heads of creeks, upon which are actually engaged several mining companies, with great success, in the collection of the golden particles that appear to be brought down by their waters from secret sources in the mountains, and deposited at every point of their course. Proceeding through the mountain regions, stone of the best character will be found, to facilitate construction and give stability to the bed of the road, at the point where solidity of construction will be most required. On the table land of Buncombe, the very spirit of health will smile upon the enterprise, and it will be hailed with joy by a flood of migration from the south, which even now sends thousands to make a painful journey to this delightful region. Descending the French Broad, (that phenomenon of topography,) we soon, by a descent entirely imperceptible, intersect the limestone formation of that vicinity; here, again, in the fertile fields of East Tennessee, a teeming soil welcomes a deliverance from her fruitful burden, and invites to the undertaking. Passing through the city of Knoxville, at the head of steamboat navigation, a new auxiliary will be opened to improve the resources of the enterprise.

The inexhaustible beds of coal and iron of the Cumberland mountains must claim attention; then the salt works at the heads of the Kentucky, and at length the west, the rich, the boundless agricultural resources of the west, even the far west, through the majestic streams that form a continuous line of intercourse, are brought into tempting contiguity with the sea ports on our Atlantic border. Charleston, Columbia, the capital of South Carolina, Knoxville, Lexington, and Cincinnati, the whole west, in fact, will thus be as neighbors. Their staple commodities will be readily exchanged, and they will become the store-houses of a region in extent, fertility, and mineral wealth, that has never been equalled in even a remote degree.

We will now proceed to an enumeration of the surveys that have been executed under your instructions, describing the various routes surveyed, and submitting the maps and profiles in illustration of those surveys, and in fine such data as we think may suffice to enable the board to form quite an accurate estimate of the properties of the various routes.

It will be distinctly borne in mind, however, that whatever reliance we may have in the accuracy of our own impressions of the comparative cost of construction by the several routes, an *estimate of cost* does not properly belong to this stage of our operations. Such an estimate presupposes a determinate *plan* of the work, which would, of course, as it necessarily

must, depend on the natural features of the country. Our object has been rather to ascertain those features, and from them to resolve the question of PRACTICABILITY (usefulness) in its extended sense of the project, than the precise route of the road, on which would be projected the ultimate plan and of course the *cost* of the work. We do *not* mean to say that surveys and our own observations have not sufficed to determine us as to the preference due to the various routes, nor that from those surveys we have not adequate data on which to decide to what route a preference is due. But we do not mean to say, that so extended have been the surveys, and so multifarious the results, that we have not had time to duly consider them, and that in fact they are not yet entirely before us. Even the results of the surveys below the mountain southward have not as yet been returned, nor could they have been, from the occupation of the numerous corps in our service elsewhere. We feel very confident which route should be adopted, and hereafter may be fortunate enough to secure a concurrence in all sections interested in our opinion; but we wish it understood that so far as *cost of construction*, usually almost conclusively, is an element in the comparison of routes, at this time it must be considered as only approximate. From the surveys and examinations which have been made, it would appear that the passage of the Blue ridge or Alleghany mountains can best be effected within the limits under consideration, at either the Butt mountain gap or the Reedy patch gap; that the Saluda mountain (*a spur in fact of the main Alleghany, although it stretches along parallel with the Blue ridge*) intercepts a direct passage of the railroad to and through the low countries, and must be *crossed* in our descent southward from Butt mountain gap, in its depression at the Gap creek gap, or turned by descending Green river, which flows between the Saluda and Alleghany mountains, when the opportunity would be availed of, to pass around the White Oak, the termination of the Saluda, in order to resume the desired direction; or, finally, it may be turned also by passing down the immediate valley of Green river by Broad river.

In the first case, that is by the Gap creek gap, having passed the Saluda mountain, the route of the railroad would be through the districts of Greenville, Laurens, and Newberry, (and pass in the vicinity of their respective court houses,) to Columbia; in the second case, it would be directed across the North and South Pacolet, to and along the Spartanburgh and Union ridges to their termination on Broad river, and thence down its valley to Columbia; in the third case, having descended the Green river, the route would be directed along the Cowpen ridge to its termination on Broad river, and thence down Broad river. Assuming the *southeastern division* of the road as the first object of attention, and referring to general map No. 1 of the mountain region, with the sectional profiles No. 1 to 22 inclusive, the various modifications of the several routes may be thus described.

Green river or middle route.

A line (A. B. B. B., &c.) descending by a grade limited not to exceed 60 feet per mile, on the north side of Green river, to attain the low ridge between Green and Broad rivers. Another (A. E. E. E., &c.) by a similar grade in the ascending direction of the valley of Green river, until the line intersects it, and thence taking down the valley on the south side of the river, it pursues the general side slope of the Saluda ridge, until it attains a

point, (Thompson's gap, at B. M. XXXIV,) and eventually emerges from the mountains on the valley of the North Pacolet, and thence proceeds, after having attained the Spartanburgh and Union ridge, to Columbia. A modification of this line, keeping down the valley of Green river to the Great falls, and thence following out the side slope at a grade limited to an inclination of 60 feet per mile, until it emerges from the mountains at (B. M. III.) Edgington's gap; thence by the Cowpen ridge to the valley of Broad river, and so, down its valley to Columbia. Another modification, to descend the Great falls by stationary power and inclined planes, afterwards, keeping for a time the valley of Green river, to diverge from it at Aldridge's, about four and a half miles below the falls, and connect with the line above referred to at Edgington's gap; and finally,

A line following down the river to its mouth, and pursuing thence the valley of Broad river to Columbia.

These are the modifications which refer to the valley of Green river.

Gap creek route, in the Saluda mountain.

This survey is common with those just described at B. M. (A. IX.) Butt mountain gap. Thence it ascends the valley of Green river (A. C. C. C., &c.) crossing it at B. M., a mile and a quarter above Murray's, and reaching the Gap creek gap by an ascending grade. Hence, there are three modifications surveyed experimentally: First, a line limited to a grade of sixty feet per mile, descending on the east side of the creek, and proceeding in an easterly direction (C. C. C., &c.) along the south slope of the Saluda mountains, until it intersects the north fork of the Saluda river. Hence it descends for a distance of about sixteen miles the valley of the Saluda, but, diverging at Salmon's plantation, attains the ridge lying between the Tyger and Enoree, and then descending keeps the crest of said ridge through a great portion of its length, until it leaves it to attain the valley of the Broad river by the valley of Padget's creek.

Modification 2d.—To leave the ridge at Woodruff's, cross the Enoree, attain the Lauren's and Newberry ridge, and thence to Columbia.

Modification 3d.—(D. D. D., &c.) To descend by the valley of the Gap creek from Gap creek gap, by inclined planes and stationary power, to the middle fork of Saluda, keeping its valley for a few miles, to the vicinity of Bate's branch, crossing the ridge between the north and middle forks of Saluda river, falling into the north fork through the valley of Beaver Dam creek; the line hence ascends the valley of Mile creek to the gap at its head, in the ridge between Reedy and Saluda rivers, known as the White Horse ridge, and reaches Reedy river, keeps down the Reedy river for a few miles, and diverges therefrom in the vicinity of Young's farm, to attain the main Laurens and Newberry ridge, hence, keeping the main ridge, the line proceeds through Greenville, Laurens, and Newberry, to Columbia.

Modification 4th.—To descend by a graded line on the west side of Gap creek, to attain the main ridge west of the Saluda, passing by Pickensville, and descending the said ridge between the waters of the Saluda and Savannah rivers, to Aiken, and thence by the Charleston and Hamburg railroad to Charleston.

Reedy Patch gap.

This route refers to a continuous line descending the Reedy Patch creek, to the valley of Broad river, and thence by said valley to Columbia; whence the line would diverge from the river, proceeding in the direction of Branchville, and so on, to Charleston.

Modification.—A line to diverge from the Broad river, above the 99 islands, in the vicinity of Cherokee ford, and, by keeping a low grade, attain the main ridge lying between Broad and Catawba rivers, and by that ridge, through Chester, Winnsborough, &c., to Columbia, and thence to Charleston, as aforesaid.

These are the general routes that have been surveyed, proceeding south-eastwardly from the summit of the Blue ridge; but various local modifications have been examined, which will be referred to in the particular description of each route; in other words, the scope of our examinations includes the whole country below the southern base of the mountains between the Catawba and Savannah rivers.

A general description of routes *westwardly*, will next be summarily stated:

From the *Butt mountain gap*, a line descending to Mud creek by Bate's fork, and keeping its valley nearly, proceeds to its junction with the French Broad. About six miles above the mouth of Mud creek, Clear creek joins it; and it is at this point that the line from Reedy Patch becomes common with that from Butt mountain. From the mouth of Mud creek, the line pursues the French Broad, on the westward side generally, although it has been found necessary to cross, in a few instances, to cut off bends of the river. No diverging line or modification occurs, until the survey reaches Newport. Here two leading modifications present themselves: the one following the valley of the French Broad and Holston to Knoxville, and thence to Wheeler's gap, in the Cumberland mountains; the other passing by New Market, Flat creek, and the end of Clinch mountain, leaving Knoxville to the left, and following the general direction to the Cumberland gap of the same range. Hence surveys are making, of which the particulars are not yet received. Generally, however, they proceed in the direction of Lexington, which is a determinate point of the route.

We now proceed to a more particular detail of the subject, and enter into a description of the routes that have been surveyed.

The line at first referred to from Butt mountain gap, descending by a graded line 60 feet per mile, on the north side of Green river, intended to attain the dividing ridge between Broad and Green rivers, and thus reach their junction, passing through Rutherford district, was run by Mr. White, so far as it has extended. No definite results have yet been procured, but thus far it bids fair to stand in powerful rivalry to the other lines of the middle route. This line might be modified to pass by a gap at the head of Jones creek, about two miles east of the Butt mountain, and of the same elevation, as some slight advantage might be derived to the project of this arrangement.

The lower part of this line, that is, from the junction of Green and Broad rivers, has been levelled, and the grade and direction are very favorable. There is an intermediate space to be yet surveyed. On this route, nine miles were run from Butt mountain gap, passing over Dodge-

ing, Jones's Mill, and Hungary creeks, without encountering more than — feet of tunnel, or a bridge of a greater elevation than 80 feet, and no curvatures of less than 600 feet radius. This portion of nine miles in fact comprises the greatest difficulties of the project by this route. The general direction of this route is very advantageous.

Green river route.

Modification.—This line has been executed by Mr. Lewis, from B. M. (Vide map No.—,) at the Butt mountain gap. Instead of descending at once in the direction of the course of the river, we caused it to be carried in an opposite direction for two objects, namely: by intersecting Green river as soon as possible, to obtain a basis in the valley of the stream, which, in the upper part of its course, affords a favorable site for the road, and to be thus enabled to render, as circumstances might require, either side slope available for our purpose; and another was, that we might adopt as a basis of operations the Saluda mountains, whose general course conformed, in a great measure, to the direction upon which it was desirable our line should proceed. Each of these desiderata have been procured, according to our expectation, in the two modifications appertaining to this route. In leaving the Butt mountain gap, the line was carried in a southerly direction, keeping the side slope of Butt mountain at a grade descending 60 feet per mile for 1.6 mile; thence by a level across a branch of Laurel creek, to a gap in the dividing ridge between Heatherly's and Laurel creeks, at Sandy Hollow; at this point a cut of 62 feet will be required. The line thence begins to descend, following the side slope of Heatherly's creek on the south side. Thus far the line has been found remarkably straight, but it now is obliged to make a turn, in order to follow down the valley of the river to which it is gradually falling. This turn is observed on the map at Heatherly's, around the point of the dividing ridge, between Green river and Heatherly's creek. The curvature at this point, although comprising a very considerable arc of the circle, has a radius of 605 feet, which is the minimum radius of this line. The survey is now confined to the side slope of the Green river, descending to it gradually, and intersecting it at B. M. No. 2.

It is at this point that the two modifications of this line diverge. We will denominate them, for the sake of distinction, the upper and lower lines. Casting your eye on the map for an illustration of what is here described, we call your attention to B. M. No. 2, in the valley of the Green river, as it is a point from which two of the most important modifications of the route diverge, the respective merits of which we shall hereafter discuss. Here we are enabled to cross the valley of the river at an elevation of 80 feet, although the line absolutely run passes at an elevation of 30 feet only. By the first plan, we should diminish the grade from Butt mountain, and avoid the ascent to a low summit which is encountered soon after leaving the river. Having crossed the river, the line ascends from B. to C. as shown on the sectional profile No. 5, and continues either ascending or on a level, to the crest of the ridge dividing Revis's Spring branch from Camp creek, about $1\frac{1}{2}$ mile from the river; and although the ground over which we pass in this distance is very good for the mountain division, yet it would have been desirable not to have been compelled to make an ascent in this direction, for, in or-

der to disengage the line from the mountain section of our route, a certain fall is necessary to be encountered, and the longer the descent of the line is postponed, the longer is it confined to the difficulties of a mountain location. On this route, however, local circumstances are fortuitous, and in a great measure justify the neglect of this principle. From Revis's, the line again descends for one mile to A. section 7, whence a level is continued for about $1\frac{1}{4}$ mile to the end of 8th mile nearly; a portion of the 9th mile ascends at a grade of 60 feet per mile, but passes over very good ground to the dividing ridge between Camp and Cove creeks, and here our ascents in this direction terminate. The dividing ridge between Camp and Cove creeks may be regarded as the second principal summit of this line. We have from this point a uniformly descending line, to the end of the mountain division. The 10, 11, 12, and 13 miles, intersecting the heads of Cove creek, involved some tolerably deep cutting and filling, but, on the whole, the ground is not very difficult. This brings us to Howard's Gap creek; up to this point no tunnel has been found necessary, and the ground may be said to have been very favorable from our point of departure. A survey connecting with the line at or near this point, to pass through Howard's gap, is now executing; it will be referred to hereafter. The passage of Howard's Gap creek forms one of the principal difficulties of this line: a bridge elevated 131 feet above the bottom of the ravine, and about 400 feet in length. After passing Howard's Gap creek, we encounter the dividing ridge between the Big and Little Cove creeks, and here a tunnel of 428 feet will be required, with a very considerable depth of cutting at either extremity. The line is now obliged to descend at our maximum grade, 60 feet per mile, in order to fulfil the condition of a good general direction, and to attain the crest of the Cowpen ridge, at Thompson's gap; for passing above that point, the line would wind round the mountain, and be carried considerably up the valley of North Pacolet, in an opposite direction to the one desired. The dividing ridge between Little Cove and Alston's creek, and the main Alston's creek, being passed, by means of a deep cut and an elevated bridge, the line was traced upon the side slope of Tryon and White Oak mountains, and encounters a succession of ridges and deep ravines, necessitating very deep excavation and embankment, and several tunnels, of all which the details are shown in the annexed table (P.) The general direction of the line is very uniform, until it reaches the end of the White Gap mountain. At this point, the line makes an abrupt bend, being compelled to follow the mountain side, to preserve the required grade. At length it reaches Thompson's gap, according to the scheme of the project; hence the Cowpen ridge is kept for about $1\frac{1}{4}$ mile to B. M. 32, which may be regarded as the end of our mountain division. This is not, however, the termination of our heavy grades upon this modification of the project, although the ground becomes decidedly more favorable in proportion as we advance. It is to be remarked that, notwithstanding this line exhibits some very expensive sections, yet, that owing to the lateness of the season at which it was begun, the greatest advantage could not be taken in regard to the selection of ground; indeed, it is shown by the data procured, that it will be quite possible to *locate the line in its whole extent from Butt mountain, without the necessity of an ascent in the adverse sense of the line*, and that the excavation and embankment will be in fact diminished by this arrangement. As it is, we

have to congratulate ourselves that a line is not only shown to be practicable, but to be effected at an expense that could scarcely be hoped, by reference to the important character of the difficulty we have to subdue. This 24 miles, which we have just described, sunders the great mountain barrier between the east and the west. The other portion of the route, extending from Charleston to Knoxville, scarcely involves difficulties incidental to ordinary railroads.

From B. M. 32, the line must now be traced in the direction of Columbia; and to effect this object, the first difficulty that presents itself is, the crossing of the North Pacolet. After having run for about two and a half miles on a level, the line commences a descent of sixty feet to the mile, for a distance of somewhat more than four and a half miles, to the point at which the North Pacolet is crossed by a bridge of 150 feet in length, and at an elevation of about 40 feet. The line, during this portion, does not conform to the crest of the ridge, but is compelled to take the side slopes, in order to approach the river, under a proper inclination. The graduation of this side slope, however, will not be found difficult, and little or no rock will be encountered in the excavations.

Having crossed the river, a grade ascending the opposite side slope, of 40 feet per mile, is adopted, which diminishes in proportion as we attain the dividing summit between the North and South Pacolet. Having crossed the river, the ground very decidedly improves, and the graduation may be effected with very little expense. The line no sooner attains this summit, than it begins to descend to the valley of the South Pacolet, upon a grade of $31\frac{7}{8}$ feet per mile. The river is crossed on a bridge of 350 feet in length, and elevated about 65 feet above the bed of the river. The distance between the two rivers is about eight miles.

From the South Pacolet to the termination of Mr. Lewis's survey at Lawson's fork, the line surveyed is only experimental, as time did not allow a location to be effected, but the nature of the ground is understood, and we have ascertained that no greater difficulty would exist upon this portion, than upon the ground between the two Pacolets. At Lawson's fork, Mr. Lewis terminated his line at B. M. 56, established there by Mr. Power, having reference to the continuation of this line descending the Spartanburgh and Union ridge to Broad river. Let us continue the description of this portion of the line. (See maps and profile.) Having crossed Lawson's fork on a bridge of about 50 feet in elevation, the line will begin to rise from its valley, and obliquely crossing the two branches, 1st and 2d Chincapin, until it reaches the crest of the ridge by a grade of $26\frac{4}{10}$ feet per mile. The direction in getting to the ridge will be good, and the line almost without curvature. The preceding description comprehends the most difficult portion of the route; thence to the Broad river, (nearly,) the line continues upon the ridge, which, however, exhibits a good deal of undulation and curved line. The grade, however, need not exceed 26 feet per mile. This, indeed, may be much reduced; for the principal eminences over which the road passed may be turned without difficulty, and without much increase of development. The grade of $26\frac{4}{10}$ feet in this approximate survey was adopted, in reference to the principal elevations, and applied to portions susceptible of a less grade, because the advantage to be gained by a lighter grade (the engine being necessarily adapted to a heavier one) would not have been commensurate with the inconvenience of a greater development or increased distance to procure it.

The line passes within a very short distance of Spartanburgh court-house and Union court-house, at a distance of, probably, less than half a mile in either case. From Union court-house, the line keeps the ridge until it gets into the vicinity of the head of Cane creek, where it passes into the valley of this stream, which is found to be extremely crooked. Mr. Kirkwood, under whose immediate direction the survey was executed, proposes a modification, by keeping longer on the ridge, and developing, so as to reach the creek nearer to its debouche into Tyger river. This line connects with the line executed by Mr. Scott, at the mouth of Tyger and Broad river. The maps and profiles, with the table of grades hereto annexed, will explain the details of this portion of the route. From the mouth of Tyger, the line executed by Mr. Scott crosses the Broad river, and continues down upon the eastern side; the object of keeping on this side being to avoid the large streams which fall in on the other. The line would be enabled to keep upon good ground without recrossing the river. The principal water-courses to be crossed at their mouths would be Little river and Cedar creek.

As the river rises a good deal during freshets, the line would have to be thrown back upon the side hills, or be sustained above the high water line by very secure and expensive embankments. The line in regard to the river portion of the route, though not run with reference to even an approximate location, affords by its detail as a topographical map, the means of forming a very good idea of the properties of the valley for the object intended. Below Columbia our surveys have not extended; but the survey of Mr. Clark, and those of Messrs. Dexter and Detmold, will furnish data in reference thereto, and enable us to form an opinion of the location.

The modification referred to by Howard's gap would be common with the line just described from Butt mountain gap to B. M., which is found to be — feet below the Howard's gap. This line, instead of turning eastwardly from the gap, in order to attain the Cowpen ridge, which had been proposed with much solicitude by the residents in that vicinity, would be obliged to turn in the opposite direction, keeping westwardly along the side slope of the Saluda mountain, and, after turning the North Pacolet, emerges from the mountains, either upon the ridge between Tyger and Enoree, or the Spartanburgh and Union ridge. It is obvious, that the project first referred to is impossible, as the line would, if carried eastwardly, instead of attaining the Cowpen ridge, at any reasonable grade, would pass far above it, and enter again the valley of the Green river.

The route we have proposed from Howard's gap would form the western limit of what is designated the middle route; it would pass very centrally through the State of South Carolina.

Green river valley.—Lower route.

The lower route of the Green river valley diverges from the line we have already described, designated the upper line, at a short distance above Revis's ford, at B. M. 2. (See map No. 1, survey of Mr. White.) Our expectations in regard to this line, so far as it confines itself to the valley of the river, are fully verified by the profile we have obtained. It is true, the river must be occasionally crossed by a viaduct, but its width is so very insignificant, and it is passed over at such a little elevation above its bed, that, by comparison with the deep chasms necessary to be surmounted, when

the line is constrained to keep the mountain side slopes, it may be regarded as scarcely an inconvenience. In order, however, to obtain this advantage in one portion of the route, that is, from B. M. 2, above the head of the Pot shoals, the line was obliged to descend at a grade of 130 feet per mile for a distance of 1.95 mile; but the location on this part is generally very straight, and it might, if such a system be thought advisable, be surmounted by stationary power, using water as the propelling agent, on a straight inclined plane of 6,246 feet in length, having a descent of 209 feet, or 176 feet per mile. From the foot of this inclined plane, a development of 49 to 54 feet per mile can readily be effected to the head of the Great falls, keeping the bed of the river throughout, and in many instances, as may be seen by the inspection of the *yellow* grade line on the profile, occupying better ground than that over which the present line passes. From the head of the Great falls, retain 1 mile 4,000 feet of the level grade which was run beyond Camp creek tunnel, and thence a grade uniformly descending at a rate of 36.4 feet to the mile can be obtained to Edgington's gap; the distance from Camp creek to Edgington's gap being 10 miles 3,400 feet, and the descent 388. By adopting this grade, the character of the line beyond Camp creek tunnel will be improved by reducing the tunnelling, and rendering the course more direct, and as good ground, if not better, will be occupied. Or, in fine, it might be modified to a grade of 60 feet per mile, and intersect the present line at a lower point, inasmuch as the grade below the foot of the plane, of 130 feet per mile, becomes much less, namely, as far as the head of the Great falls, varying from 24 to 60 feet per mile, and thence to Edgington's gap, averaging 36; but, in that case, it must be observed, we should lose the valley of the river as our basis. The distance from B. M. No. 2, to the head of the Great falls, is 5 miles 3,500 feet. At this point, B. M. 10, two lines diverge, one descending the Great falls, examined with reference to inclined planes, of which the plan and profile are here with submitted; the other continuing, by a graduated line, to confine itself to the side slope of the mountain; and, of course, at this point leaving the bed of the river, which falls in a ratio too great for the project, in reference to locomotive power. At B. M. 10, therefore, pursuing the description of the route for locomotive power, as already designated, the line is carried upon a level for a distance of $2\frac{1}{2}$ miles, in order to avoid a greater length than necessary in a tunnel, that must be encountered at Camp creek, 615 feet in length. Without dwelling, however, upon minutiae, we will describe the remaining portion of this mountain line, say to Edgington's gap, as being, in its general character, broken and difficult; although, between the principal obstructions, Camp creek, &c., we have some very favorable sections. These difficulties, however, are such as will be always encountered in any mountain section of country; the curvatures, moreover, are, in all cases, as great as 603 feet in radius, which is, in fact, the minimum limit on any of our locations.

Having arrived at Edgington's gap, Mr. White connects his line with B. M. 3, which had been established there by preliminary surveys, to determine the ratio of grade that might be adopted in prosecution of the present line. We may now be said to have emerged from the mountain division upon this route, as we are enabled to proceed hence upon good ground, with undulating grades, for about nine miles to the summit of the Cowpen ridge, after which the line has no further difficulties to contend with to the valley of Broad river.

The route from Edgington's gap to Broad river is not yet plotted, but will be submitted in time, that you may form an estimate of its advantages. The ridge is about — miles in length, and the direction is extremely favorable; added to which, the surface of ground along its crest is very uniform. —(See map and profile hereto appended, with the annexed tabulated statement.) The principal difficulties on this ridge for — miles to Gilky mountain, are — creek, which may be turned without much deviation from our course, and Cherokee creek, which is turned by our line without difficulty. Thicketty mountain may be passed with a favorable graduation; and from Gilky mountain to Broad river, although the line was carried over rough ground, its object being at the time merely experimental, and having reference only to a general estimate of rise and fall, allowances must be made. This route may be modified in two ways, namely, by descending the valley of the Broad river to Columbia, or by crossing the river and ascending the valley of Bullocks creeks, and by a graduated line, reach the leading ridge, and pass through Chester and Winnsborough. The maps and profiles which will accompany this report, will enable you to judge of these respective advantages. As yet the data are not handed in to this office. It may be remarked, as a general feature of this line by the Cowpen ridge, that it attains the Broad river below the *Ninety-nine islands*, and thus avoids the only difficult point on the river.

Gap creek route.

The different lines of survey, having reference to a passage of the Saluda ridge at this gap, consist of a line from Butt mountain gap, descending to the Green river, and crossing it above Murray's farm, and then rising to the summit in question, which is 19 feet above the B. M. at Butt mountain. The profile over this immediate ground, though not as irregular as some other portions of our mountain locations, may yet be regarded a very expensive section. The line descends to the Green river by a grade averaging 30 feet per mile, and thence rises to the gap at a grade of 40 feet per mile. The distance is about 8 miles. Hence a line descending at the grade of 60 feet per mile was followed out in an easterly direction, on the side slope of the Saluda mountain.

In giving instructions that the line should be prosecuted in this direction, our object was, that it should attain the valley of the Saluda river as early as possible, in order to render available the gradual slope of bottom land which lies at a considerable elevation upon this river. This object has been gained, although the development has encountered some very heavy excavation and embankment, and a considerable amount of tunnel. We are led to believe, from the character of this experiment, that it would be extremely difficult to effect a good location for locomotive engines upon this route; other modifications, however, have been suggested, and notably, one by which the line would turn at what is termed the "State Place," indicated upon the horizontal projection of the survey; and returning generally along the side slope over which it had passed, develop itself upon Saluda mountain at a lower point. If it were thought desirable that this survey should be made, it would probably intersect the lines to be hereafter described, becoming thus one of their modifications. The survey just referred to, having once reached the valley of the North Fork, has a beautiful run for several miles in its valley to Salmons, where it leaves the river to obtain the

ridge lying between the Tyger and Enoree. The maps and profiles are not yet completed. It will be sufficient to say, in justice to this route, that to the junction of Broad river, 77 miles from where the line strikes the ridge, in the vicinity of Stroud's, on the Saluda river, few or none of our routes can exceed it in evenness of profile, and that from the point where the line reaches the valley above Hodges to Strouds, no exception can be taken to the profile.

The most feasible method of rendering this route available, however, would be, by reference to inclined planes, if such a system should be thought advisable. It was in this point of view that the first survey was made, although, owing to the objections generally entertained against this scheme of traversing the mountains, we have been desirous of showing every proper development that could afford us the hope of a descent upon this route by locomotive power. There is a descent in the Gap creek of nearly 1,100 feet to its junction with the Saluda; this occurs in a horizontal distance of $6\frac{2}{3}$ miles. Now this may, with cutting and embankment, be resolved into two, or at most three, inclined planes, for the application of stationary power, with intermediate grades for locomotives; for, except in one portion, consisting of less than half a mile, the general direction of the creek is nearly straight; on the last two miles before its junction with the Saluda, the grade becomes much lighter, and the fall may be developed upon the side slopes. Having reached the middle fork of Saluda, the line would follow its valley, and passing over Waldraps ridge fall into the north fork, thence by Bates branch into Reedy river, and leaving Reedy river attain the main Laurens ridge, as already described. These three intervening ridges are too much elevated to permit a grade within an expedient limit to pass over them, upon the line run; but it is not impossible that a development to pass round them might be effected. The continuation of this line upon the Laurens ridge to Laurens C. H. has not yet been reported on by the assistant engineer employed on the survey. The line below Laurens C. H. to Columbia has been retarded by adverse circumstances, (sickness of the assistant,) and the data in reference thereto are not yet before us. The returns will probably be made in readiness for the meeting of the stockholders.

Among the modifications relating to the Gap creek summit, it was deemed possible to procure a line that might develop itself upon the ridge lying between the Saluda and Savannah waters, not only by diverging from the Saluda at a lower point of its course, but by carrying a graded line from the summit level expressly with that view. As soon, therefore, as Mr. Drayton was disengaged from his surveys on the French Broad, he received instructions to commence a survey at the B. M. formerly established by himself at the summit of Gap creek, and carry a graduated line, varying according to expediency, as governed by a judicious selection, between 40 and 70 feet per mile; and, at the same time, surveys were commenced at Aiken in reference to both these projects, one to attain the most advisable point of the valley of the Saluda, the other to ascend the leading ridge west of the Saluda, to meet the line referred to, which would attain the ridge above Pickensville. In regard to the latter line, the report from Mr. Drayton (who superintended the survey from Gap creek summit) was very unfavorable, and the line was discontinued after its properties in a reasonable distance had been ascertained. Under any circumstances, however, the shortness of the time which intervened to the meeting of the directors did not enable us to make further investigations in reference

thereto. In regard to the upper portion of the second line, referred to in this direction, it had not proceeded sufficiently to form an estimate of its advantages. It will, moreover, depend upon the adoption of the descent by Gap creek, and may be, therefore, regarded as an ulterior consideration.

From the summit of *Reedy Patch*, which we have examined in reference to inclined planes, with stationary power, we find we are enabled to descend upon a straight line through a vertical distance of 701 feet in a horizontal of $4\frac{3}{4}$ miles. The excavation and embankment will be shown in detail in the annexed tabulated statement. After getting to the foot of the *Reedy Patch*, a somewhat contracted curve will be necessary to fall into the direction of the *Broad river*, and a distance of $\frac{3}{4}$ mile will be passed over by locomotive power to the head of the inclined plane on the latter. This distance comprises 5 inclined planes, which it would be necessary to surmount by stationary power, as the grades are too steep for the most powerful engine to work, with proper effect. The grades consecutive from the summit, are as follows :

Inclined planes, Reedy Patch and Broad river.

LENGTH.		GRADE.	
Miles.	Feet.	Per mile.	
1	900	Level.	Straight Reedy Patch planes.
	4,700	163.48 feet.	
2	1,000	Level.	
	4,400	59 feet.	
3	1,400	Level.	Curved line, uniting R. P. and B. R. planes.
	3,800	277.88 feet.	
4	1,400	Level.	
	1,800	498.99 feet.	
5	1,800	Level.	Straight line Broad River planes.
	4,200	163.68 feet.	
6	4,700	39.6 feet.	
	500	Level.	
7	5,600	301 feet.	7 $\frac{1}{4}$ miles and 700 feet from summit of <i>Reedy Patch</i> gap, thence descending by a grade of 40 feet per mile.
	1,800	Level.	
	1,800	322.66 feet.	
	700	Level.	

The cutting and embankment to effect the design are less than might be expected, and it is supposed that a great deal of excavation in rock may be avoided by a tunnel of 400 feet, which is the greatest obstacle to be encountered upon this project. From the foot of the inclined planes on *Broad river*, there will be no grade over 40 feet per mile, and this may be developed to a grade of probably 30 feet per mile, during the upper part of the location below the inclined planes. It appears, however, that there would be great difficulty in getting out of the valley of the river, or at least, that to do so the line would be intersected with streams and ravines to the degree to render the project extremely expensive. It would probably keep the river valley, therefore, which is crooked and difficult, to the head of the 99 islands, and thence pass out upon the *York and Chester* ridge, by a route

to be hereafter referred to, and of which this may be regarded as a modification. From the summit of Reedy Patch westward, a line descending $1\frac{1}{2}$ mile at a grade of about 50 feet per mile, and thence by the valley of Clear creek on a grade of about 9 feet per mile, to a point (common to the line which passes from Butt mountain to the French Broad) at the junction of Clear creek with Mud creek. The profile of this line is unexceptionable, the greatest difficulty being the number of bridges to be encountered; the line necessarily crossing the creek 13 times.

Route westward by the French Broad.

We will now describe the character of the line we have examined westward from the Butt mountain gap to its intersection with the line of which we have already spoken, from the Reedy Patch by Clear creek, and thence, descending by the French Broad river, to the point where the Tennessee line intersects the survey; beyond this point the returns from the office in Knoxville are not yet received, although we shall be enabled to give a general sketch of the operations in that quarter, from the desultory data that have been from time to time communicated. The maps and profiles are expected daily, and will be laid before you, from which you will be enabled to arrive at conclusions. From the B. M. the line runs in a direction nearly north, and falling into a branch of Mud creek, called Batch's fork, it pursues a very good direction, with very slight curvature and inconsiderable excavation or embankment, to its junction with Mud creek, a distance of five and a quarter miles. The grade is, for the first one and three quarter mile descending from the gap, 30.7 feet per mile, after which it is only 7 feet per mile, and continues in a similar or less ratio throughout the greatest portion of the line; the more minute particulars will be illustrated by the maps and profiles, and the table of grades hereto annexed. There are but few irregularities of ground encountered upon the upper portion of the river, and they are of so light a character that no other comment will be required to illustrate them than the data herewith collated. There are but two crossings of the creek to be encountered upon this line, and, although occasionally swampy, there appears to be a good foundation for the bed of the road. Having reached the Clear creek at a point where the survey from the Reedy Patch and this line fall into one, the location continues down the valley of the stream upon large curvatures, and during a distance of three miles upon a straight line, until it strikes the French Broad, at a distance of thirteen miles from Butt mountain gap. Below the junction of Clear creek the line only crosses the stream once, to its junction with the French Broad; hence the line is straight for one and a half mile, and passes over a level bottom; in this distance the line encounters the Cane creek, just above its outlet into the French Broad. It is useless to describe the profile in this part of the route, or, indeed, from the summit level, otherwise than by regarding it as an inclined plane of a descent slightly inclined, so regular and united that no difficulty presents itself to the most favorable location. At the fifteenth mile, however, the road is somewhat more constrained; it is compelled to approach nearer the river, and the curvatures are more restricted; just above the sixteenth mile we encounter a curve of one thousand feet radius, or a very rocky cut; below this the curves are generally good, and the line passes mostly over bottom land, encountering an occasional rocky point jutting into the river,

but no cutting of any importance, compared with the anticipations of former estimates. One of the most difficult portions of this upper section of the French Broad consists in the passage of the Swannano river, in connexion with a curvature of eight hundred feet radius necessary to prevent an oblique crossing of this stream. No peculiarity of note occurs beyond this point to the head of the shoals above Alexander's tavern. At six miles above Alexander's, the line begins to fall at a grade of 30 feet per mile, and continues to descend in that ratio upon a distance of about one mile, after which the line resumes its gentle descent to the B. M., at which our surveys commenced last summer, four and three quarter miles below Ashville. The line crosses the river at B. M. B. 1., at which point Mr. Drayton's survey commenced; here a viaduct of six hundred feet in length would be required; for a distance of three miles the line descends on a grade of twenty feet per mile, keeping near to the river, on the side slope; having descended from the end of the third mile by a grade of thirty feet per mile, to Alexander's bridge, the fall again becomes gradual, and follows alternately the side slopes and bottoms as was deemed advisable. The line on the west side of the river, to which we now refer, possesses decided advantages over that on the east, which has also been run experimentally; moreover, it does not embarrass the turnpike road which is situated on the latter, and would have to be purchased, were the line located on the same side. Casting your eye over the map, you will perceive at a glance that there is no curvature sufficiently abrupt upon the river to give the slightest difficulty; indeed, whenever a point occurred that appeared in the least degree equivocal, an accurate survey was directed to be made of that portion in detail. The average width of the river is about four hundred feet in this part of its course. No stream of any consequence is met with, until the line reaches the mouth of Sandy Mush creek, where, in order to avoid a rocky ledge, the line passes over to an island, situated at its mouth, and is traced upon its length about sixteen hundred feet, when it again crosses to the west side. The extra bridge to effect this, would probably be cheaper than to encounter the rock excavation on the river. Above Sandy Mush creek, as high as Hughey's, the ground is very rocky, and would require expensive construction. Below this the ground is of so uniform a character, alternating between cliff and bottom land, that to describe it minutely would be a continued repetition of details, which will be found at a glance either in the tabular statements, or the maps accompanying the present report. Having reached a point opposite Brooks's, the ground for about sixteen hundred feet is very broken; the cliffs jutting into the river must be met by heavy cutting, to surmount them. The line afterwards encounters ground similar to that already described, and passes over several streams on which short bridges would be required. At the Mountain island, above the Warm springs, a point of some difficulty will occur, but it has been rigorously ascertained to be practicable with a curvature of large radius. The descent in this part is between twenty and thirty feet per mile.

Below this the line attains the bottom land adjacent to the Warm springs; hence to Faggs island the ground is good, to which the line was crossed merely to expedite the survey, and from this point no obstruction of consequence is encountered to the Tennessee line, at B. M. M. 1. On the portion of river below the Tennessee line, which was executed by Mr. Greene, it will be perceived that the curvatures and profiles are favorable. The

cliffs on the left bank opposite to Davis farm will force the line across the river at Davis neck, returning again to the left bank, requiring two bridges, each six hundred feet in length. There are three points, only a short distance above Newport, where there will be some heavy work by reason of cliffs jutting into the river, and at other points a little walling will be required. Mr. Green connected his line one and a quarter miles above Newport, with Mr. Schenk's line, conducted under the general direction of Mr. Cheesborough, the senior assistant on the work. The returns on this division of the work are not yet made, but we are enabled to embody, from general description of surveys, the principal features of his operations. Taking up Mr. Schenk's line passing through Newport, two continuous routes have been surveyed, one via the French Broad river and Knoxville, to Wheeler's gap, and the other via Newmarket and Flat Creek, (or the end of the Clinch mountain,) to Cumberland gap. On either route, a number of formidable ridges intervene, running parallel to the Smoky (or Unaka) and Cumberland mountains, and extending from south of Knoxville, north-eastwardly into Virginia. The only line by which these may be entirely avoided, would be, to follow the French Broad, Holston, &c., to Kingston, thence up the Clinch river and Cove creek to Wheeler's gap, or up Powell's river to the mouth of Gap creek, in order to reach Cumberland gap. This route being four times the length of a straight line drawn between its two extremities, renders it too circuitous to merit consideration. With a view to crossing Cumberland mountain at Wheeler's gap, the route from Newport through Knoxville seems the fairest compromise between distance and elevations, and presents the most eligible route. Commencing at Newport, this route crosses Big Pigeon river about three miles above its mouth; thence it approaches the French Broad, and, crossing it at the mouth of Seekorn's creek, follows its northern bank to a little below Dandridge. The line here leaves the river, and, striking it again at Dumpling creek, is continued down the river valley to the Holston. Crossing this stream, the route is traced in its right bank to the mouth of Trust creek, thence up this creek to Knoxville. From Knoxville, the line is conducted along Second creek, Beaver creek, and Upper Dismal branch, crossing Pine, Black, Oak, Copper, and Chestnut ridges, and striking the Clinch river at the Eagle bend; thence it follows in the valleys of Clinch river, Cane and Cove creeks, to Wheeler's gap. From Newport to Knoxville, the grades do not exceed thirty-nine feet to the mile; thence to Wheeler's gap, no grades higher than sixty feet per mile occur, except in a few instances, where it will be a question of calculation, whether to adopt inclined planes with stationary power, or to develop on the slope of the ridge, for locomotive grades. The line, as it is run, involves some inclined planes, varying from one hundred and ten to two hundred and thirty feet to the mile. The distance from Newport to Knoxville is 51.85 miles, thence to Wheeler's gap 48.50 miles, making the whole length 99.36 miles. Should Cumberland gap be eventually selected as the best point of passing the Cumberland mountains, the route by Newmarket and Flat creek is decidedly to be preferred. Beginning at Newport, it follows the south side of the French Broad to one and a half mile below the mouth of Notichucky, where it crosses the river. Thence passing the depression in Bay's mountain, at Wausfield gap, and south of Newmarket, the route is conducted across the Holston river, at the mouth of Flat creek, and following the valley of this stream fourteen miles, it pierces Copper and Hind's ridge, pursues Dobson's

creek to its mouth, and crosses to the north bank of Clinch river. Following up the river bank and Big Barren creek, the line crosses the dividing ridge near R. Harper's, and passing down Sinesome valley, it crosses Powell river, and is traced up Gap creek to the Cumberland gap. The distance from Newport to the mouth of Flat creek is 43.31 miles, thence to the summit of the mountain at Cumberland gap, 48.25 miles; making the total length from Newport to Cumberland gap, 91.56 miles. The grades between Newport and two miles south of Newmarket need not exceed thirty-five feet to the mile. Thence to the base of the Cumberland mountains, grades of sixty feet are encountered, and two inclined planes will be required, or a developed distance for locomotives, one on the north side of the ridge, the other on the northern slope of the ridge, between Powell and Clinch rivers.

From (Mr. Green's B. M. (M.) which is about one mile above) Newport to Wheeler's gap by Knoxville, the distance is 100.26 miles, and the amount of ascents necessary in the grades is 1,738 feet. Wheeler's gap, that is the proposed tunnel, is 580 feet above Newport; consequently, the total amount of descents necessary in the grades is 1,158 feet. From the same point to Cumberland gap by Flat creek, the distance is 91.56 miles, and the total amount of ascent necessary in the grades is 1,900 feet. The tunnel at Cumberland gap, say 80 feet below the summit, is 560 above Newport, and the amount of descents in the grades is consequently 13.40 feet. It is highly probable that further examination would lead to considerable improvements in some portions of this route, but, in order to furnish in season the general results, the consideration of points of minor importance was necessarily omitted.

The surveys in Kentucky have been advancing as rapidly as circumstances would permit. Mr. McKee, who has had the immediate management of the surveys in that quarter, under the senior assistant, E. S. Chesbrough, reports, however, that examinations have been made, which will greatly facilitate future operations, in reference to the location of the road. The result of the various examinations is, that (in reference to the Wheeler's gap, and a route by Williamsburg on the Cumberland river) the line must pass the dividing ridge between the Cumberland and Kentucky rivers, either by the heads of Scagg's or Dick's river, or between the head waters of Round Stonelick creek and Silver creek, and that it will enter the Rock Castle river by the valley of Little Rock Castle; and that the valleys of Dick's river, Pant lick, or Silver creek, could not be followed without great difficulty, out to the junction with the Kentucky river; and that it would be equally difficult to descend the Kentucky river to the mouth of Hickman's branch, and thence ascend to Lexington by its valley. The line he has surveyed, of which the levels are annexed to my report, would pass from Williamsburg up the valley of Watts's creek, falling upon the head of Lime Camp creek, and thence crossing the valley of Big and Little Laurel creeks, to the vicinity of London. This line would have to traverse several summits, namely: between Watts's and Lime Camp creek, Horse creek and Robinson's creek; between the Big and Little Laurel, and the high ground in the vicinity of London. The line would then fall upon Laurel branch, Hazle Patch fork, and into the Little Rock Castle, and thence descending by the Big Rock Castle to the mouth of Scagg's creek; following the valley of Scagg's creek, the line would attain the summit, Tavern Spring branch, lying between the waters of Kentucky and Cum-

berland rivers; thence it descends, falling upon Negro creek, a branch of Dick's river, pursuing it to its mouth, and down the valley of Dick's river to the vicinity of Crabb Orchard; below this the line passes into Drake's creek, and following its valley, passes over in the neighborhood of Lancaster to Sugar creek; thence it follows down the valley of Sugar creek to the Kentucky river.

The surveys from Wheeler's gap to the Cumberland river are now in progress, and returns are expected daily. Neither have returns been made in reference to the western descent of the Cumberland gap, but our personal reconnoissance of the route through Kentucky, passing from this gap to Lexington, enables us to expect the most favorable results.

The maps and profiles, just arrived, enable us to afford a more accurate description of the portion of our line extending from Williamsburg to Lexington, on the Kentucky river. Beginning on Cumberland river, about $\frac{1}{4}$ mile below Williamsburg, the line descends the river on nearly a level to the mouth of Watts's creek, a distance of about $1\frac{1}{4}$ mile; at this point we leave the Cumberland, and ascend the valley of Watts's creek, to the ridge between it and Lime Camp creek, a distance of about 11 miles, with a grade of nearly 22 feet to the mile. Crossing this ridge, we descend the valley of Lime Camp creek to the mouth of Horse creek, distance 7 miles, grade 12 feet per mile. Ascending the valley of Horse creek, to the ridge between it and Robinson's creek, we rise at the rate of 36 feet per mile, for a distance of $3\frac{1}{2}$ miles. From this ridge, we reach the bed of Robinson's creek in a distance of $1\frac{1}{2}$ mile, with a descent of 100 feet. From the valley of Robinson's creek to the summit between it and Big Laurel river, the distance is $1\frac{1}{4}$ mile, and the rise 90 feet; from this ridge we reach the valley of Big Laurel in a distance of 600 yards, with a descent of 100 feet. We thence ascend Stanbury branch of Big Laurel river, reaching the summit between it and the waters of Little Laurel, ascending at the rate of 40 feet per mile for $2\frac{1}{2}$ miles. The valley of Little Laurel is reached from this ridge in a distance of $1\frac{1}{4}$ mile, with a grade of 22 feet per mile. The line is carried between the valley of Smith's branch and Laurel branch of Little Laurel river, to the ridge near London, in a distance of $5\frac{1}{4}$ miles, ascending at the rate of 18 feet per mile. The descent from this ridge to the valley of Wood's fork is effected with a grade of 53 feet per mile, for the distance of $2\frac{1}{4}$ miles. From this stream, the line ascends to the ridge between Wood's and Hazle Patch forks, a distance of $2\frac{3}{4}$ miles, at the rate of 12 feet to the mile. The descent from this ridge to the mouth of Little Rock Castle river, formed by the confluence of the above mentioned forks, is 346 feet; the distance is $8\frac{1}{4}$ miles, giving for the rate of descent 42 feet per mile. We then descend Rock Castle river to the mouth of Scagg's creek, falling 13 feet in a distance of $5\frac{3}{4}$ miles.

From the mouth of the latter stream, along the valley of which the line runs, to the gap in the main dividing ridge, between the waters of the Cumberland and Kentucky rivers, the distance is 16 miles, and the rate of ascent 23 feet per mile.

The line then descends the valley of Negro creek, to its junction with Dick's river, and follows the valley of the latter stream to the mouth of Drake's creek; giving, in this distance of $13\frac{1}{2}$ miles, a grade of 28 feet per mile. We then ascend the valley of Drake's creek, to the summit between it and Back creek; this distance is $5\frac{3}{4}$ miles, and the rate of ascent 25 feet. Crossing the valley of Back creek to gain the head of Sugar creek, we

descend 157 feet in $1\frac{1}{2}$ mile, and ascend 120 feet in $1\frac{1}{4}$ mile. From the latter summit, we follow the valley of Sugar creek to Kentucky river; descending 542 feet in 11 miles: that is, at the rate of 49 feet per mile. We then ascend Kentucky river, on nearly a level, to a point near the mouth of Paint Lick creek, a distance of 3 miles. Crossing Kentucky river, at the mouth of a small stream called Lick branch, we ascend the ravine of this stream, rising at the rate of 125 feet per mile; at a distance of 2 miles from Kentucky river, a junction was formed with the line run from Lexington by Mr. Chinn.

We will next enter into a few general remarks, on the subject of one of the most interesting portions of the whole enterprise, namely, *the passage of the Blue ridge*, which must determine the general direction of the line through South Carolina. The *point of the Blue ridge at which the south-eastern division of the road shall traverse the mountains*, and the *point at which the Cumberland mountains shall be surmounted on the north-western division*, constitute the *pivots* upon which the general location of the enterprise must turn, and they naturally are looked to with intense anxiety.

In regard to the summits or gaps of the Blue ridge, to which any line of railroads passing into North or South Carolina must necessarily conform, we have ample data before us to resolve our minds. It is true that time is not awarded us, before the meeting of directors, to make as elaborate a report as even the materials before us might warrant; but the opportunity will be afforded us of explaining to the stockholders and the directors every circumstance of topography, at least, that may enable them to come to a decision upon the question. It will be admitted, on general principles, that the more elevated the point at which we are compelled to rise, previously to making one descent, or, in fine, the higher the summit level, the greater is the increase of difficulty to be encountered. This, however, although admitted generally, does not, perhaps, carry with it, at a first glance, the importance that it appears to us to deserve. This arises from two causes: First, (particularly if a graduated line for locomotives be involved in the scheme of descent,) it will be remembered that the cost of the road, in the mountain division, is increased according to the inverse ratio of descent by its greater development; that is, on a grade, say of 60 feet per mile for every 60 feet of rise and fall. The length of mountain construction, with all its attendant expenses of cutting, bridging, and embankment, is increased two miles; and that for every (say) 25 feet of vertical rise, the equated horizontal distance, in reference to economy of trade, is increased one mile; so that, to shorten our distance, every possible effort should be made to reduce our summit as much as possible, consistently *with a proper agreement of local circumstances*.

We shall endeavor to show in what degree it ought to apply to the particular cases under consideration. The Butt Mountain gap is found to be 53.8 feet below the Reedy Patch gap. The next consideration is the relative horizontal distance. And thirdly, the characteristic features of the route, by reference to the difficulties of the work, or cost of construction. From the point where the two lines surveyed come together, on the west of the Blue ridge, to a similar point on Broad river, at the mouth of Thicketty for example, one line passing by Butt mountain, the other by Reedy patch, the distances are as follows, according to accurate survey.

	Miles.	Feet.
From B. M. mouth of Clear creek to Reedy patch -	8	2,640
" head of Reedy patch to its mouth -	5	1,266
" mouth of Reedy patch, by Broad river, to mouth of Green river -	28	
" mouth of Green river to mouth of Thicketty -	50	4,000
	<u>93</u>	<u>2,153</u>
From same point to Butt mountain -	7	
" Butt mountain to Edgington's gap -	22	1,950
" Edgington's gap to McFarlane's -	9	4,423
" McFarlane's to mouth of Thicketty -	47	4,447
	<u>87</u>	<u>260</u>

Thus it is seen that the distances respectively are 93.2 miles, 87.2 miles, making a difference in favor of Butt mountain line six miles. To which, if we add 2.5 miles, according to the usual method of computing the equated distance, arising from its greater elevation, we arrive at the conclusion that, all other things being equal, the distance by the Reedy Patch gap is greater than by the Butt Mountain gap, 8.5 miles; and that, upon another principle referred to, there would be a greater cost of construction, owing to the line being confined to the mountain division in a greater portion of its development. This shows the comparative advantage of the routes in point of distance, and on general principles; but if local circumstances be regarded, the difference in favor of the Butt mountain is greatly more essential. The distances have been estimated in the supposition of an inclined plane with stationary power, ordinarily introduced to shorten the distance, and we have compared it with a route, on which the average descent would be in fact only 45 feet per mile, by locomotive power. It has, therefore, received every advantage in the comparison. In addition to this, it must be observed that the means of descending by locomotive power, from the Reedy patch, is wholly denied us by circumstances of ground, or, at least, rendered so difficult by the well known escarpment of rock that stretches for a long distance below the mouth of the creek, and which appears to frown defiance to every attempt at even a lodgement upon its inaccessible sides. If the line gets down to Broad river, by inclined planes with stationary power, as exhibited to the best advantage on plan and profiles No. —, it finds itself enclosed in the valley of the river, which is scarcely surpassed for ruggedness of character by any mountain torrent. To get out without immense cost would be impossible, the ground on either side being elevated and intersected by streams deeply indented in their ravines.

Having concluded the comparison between these lines, it will be observed that we do not announce the line of the Butt mountain as the best modification of that route, but have chosen it because its relative position renders it more appropriate, as an element of comparison. Comparing the several modifications of the Green river route, and that by the Gap creek summit, and considering, as before, the elements of *elevation, distance, and difficulty* of construction, we have the following facts; *that the Gap creek summit is nineteen feet in absolute elevation above the Butt mountain; that any line passing over Gap creek summit must first pass the valley of Green river to*

attain it; that the line, after having descended to the valley of the river, must again (instead of proceeding down to the level of the low country) rise to a summit even more elevated than the one from which it had departed; and thus having passed over upwards of eight miles of ground, little inferior in difficulty to our worst mountain sections, the line finds itself elevated 19 feet above its position at starting, and from whence there was nothing interposed to prevent a direct descent to the level country at the base of the mountains. We will illustrate this position, because it is one of vital importance in the determination of this interesting question. Two lines start simultaneously from the Butt mountain gap, and each has proceeded eight miles. The first has reached the summit of the Saluda, at an elevation of 1,113.24 feet above the base of the mountain; the other (at nearly the same cost of construction) a point only 599 feet above the same horizontal plane. The true mode, therefore, of estimating the relative elevations of Butt mountain and Gap creek, by reference to cost of construction merely, as summits for the railroad, under existing circumstances, is according to the proportion 599 to 1,113.24; or, which amounts to the same thing, you have to add to the elevation of Gap creek the whole rise that takes place from Green river valley to this summit, before you can institute a just comparison in regard to their elevations, by reference to their adoption to the object proposed.* In regard to the difficulties of location, we must refer to the maps and profiles.

The survey, executed by Mr. Colcock, to descend by a graded line, falling at the rate of 60 feet per mile, exhibits results not so much of importance in regard to the particular location surveyed, (because the remark equally applies to this as to other surveys, that the modifications on each route are very numerous;) but as indicative of the character of the mountain slope, and general circumstances of topography, in connexion with any other line that might be attempted to traverse the Saluda mountain by this summit. In fine, our results show a line of considerable difficulty.

Upon this route we have from accurate measurement—

	Miles.	Feet.
Form Butt mountain to Gap creek summit - -	8	650
" Gap creek summit to mouth of Gap creek - -	6	4,260
" mouth Gap creek to the North Fork Saluda - -	10	
" North fork Saluda to Reedy river - -	3	
" Reedy river to B. M. near Greenville - -	18	2,361
" Greenville to Columbia, estimated approximately (survey not completed) - - -	112	
	<u>158</u>	<u>2,991</u>

Green river route.

	Miles.	Feet.
From Butt mountain to Thompson's gap - -	22	4,427
" Thompson's gap to North Pacolet - -	9	2,464
" North Pacolet to South Pacolet - -	8	
" South Pacolet to Lawson's fork - -	11	1,722
" Lawson's fork to Spartanburg - -	5	4,400

* This computation refers to cost as construction, abstraction made of the element—of economy of trade—which belongs to other considerations.

			Miles.	Feet.
From Spartanburg to Union	-	-	28	4,160
" Union to mouth of Tyger	-	-	22	3,840
" Mouth of Tyger to Columbia	-	-	45	030
			<u>154</u>	<u>123</u>

Thus, the difference between the routes by Gap creek and Green river, or middle route, respectively, is 5 miles in horizontal projection. But if we equate the difference of rise and fall, the difference will be considerably increased. For example, the rise from Green river valley, where the line between Butt mountain and Gap creek crosses it, is 169 feet, counted from the surface of water in Green river; we have, therefore, difference of distance as measured on horizontal projection - 4 m. 2 f. Difference of elevation of two lines equated 169 feet - 6 nearly.

About 10 miles.

Giving a difference of distance in favor of the middle route of 10 miles. It is to be observed, however, that the graded line would pass at an elevation above the river of 75 feet; but this advantage would be purchased by the construction of a viaduct of this elevation, and 705 feet in length, with a considerable excavation at either extremity. At this sacrifice the equated distance would be reduced to 3 miles, and we should have between the two routes a difference of 7 miles.

We have, therefore, compared the different routes surveyed, by reference to their leading features, rather than by analyzing them, in reference to detail, for we regard it as futile to make any elaborate comparison of minutiae, when the objects of comparison themselves are so strikingly characterized by their most important features. These details, in order to render our report as concise as possible, are condensed in the tabular statement hereto annexed, to which we beg leave to invite attention, in illustration of our report. The circumstances of topography, however, involved in a selection of routes, are not confined to the mountain section exclusively, but belong to the whole route. For example, the ridge, on which the Gap creek line, by one of its modifications, would descend to Columbia, has advantages, by reference to the fact, that it may be rendered available in its whole length to Columbia; whilst, by the other routes on the east of the Broad river, the ridges abut upon the river at various points above Columbia. The just mode of comparison will, therefore, be to allow the lower sections of each line equally to enter as an element. Now, without entering into details, it is ascertained that the upper ridges (namely, the Cowpen, Spartanburgh, and that between Tyger and Enoree) are extremely favorable, so far as their length enables them to subserve the purposes of the road: hence, supposing the routes equal in advantages, whilst confined to the ridges, the difference in cost of construction, arising from this circumstance, will lie between the cost of a portion on the river, and an equal portion, say 54 miles, on the ridge, counted from Columbia. And the question resolves itself into this, whether the expense of construction on the river is sufficiently great to neutralize the superior advantages of the passage of the mountain. Now, all who are interested in this section know well the character of the country in these several directions. The river route, for 54 miles, would have the advantage of grade, and, consequently,

economy of trade, to make up for a greater cost of construction in the bridging necessary to the passage of the river, and of an occasional stream, that may intersect the line at its debouche ; but this we should not estimate at a greater difference of cost than \$2,000 per mile, amounting to a sum that would scarcely exceed the cost of a single mile of our most expensive mountain construction.

All this, however, relates to the respective advantages of the routes in relation to their cost, and the cheapness and facility of transit upon them. Other elements may enter, which may show the subject in a different light, but these belong to considerations on which it would be supererogatory on our part to enter. It will be seen by reference to our data, that no plan for the descent of the mountains has been admitted, not that we felt sanguine in regard to them all, but knowing how much solicitude was entertained by the stockholders of the various sections, we regarded every development as so much calculated to satisfy public opinion, and concentrate the good feelings of the community towards the enterprise.

The comparison between these main routes having been generally instituted, the particulars by which the details of each may be understood will be found, as before stated, in the condensed tabular statement hereto annexed.

In regard to the relative advantages of locomotive and stationary power on inclined planes, this is a question that does not properly belong to the present report ; it will be time enough when it becomes a question of the minutiae of a location, to investigate the subject in reference to expediency. And it will become a matter of scientific calculation as to which ought to be preferred : as there is, however, a decided predilection in the community, whether founded on prejudice or otherwise, we will endeavor to show that such an auxiliary will not be necessary to the projected enterprise. The following results, as to the power of locomotives on steep grades, will be sufficient to satisfy the mind upon this point.

It may be remarked, that there has been, and even at this day there exists generally, a misconception of the power inherent in locomotives for the ascent of inclinations, because it is asked, "Why are inclined planes with stationary power ever adopted, with all the imperfections and inconveniences so universally attributed to them ?" And the inference naturally is, that there is not a faculty resident in them, to surmount such grades. It arises, however, from this fact, that engines of the proper weight and power have not been regarded as expedient upon the ordinary character of roads, and would be incompatible with economy of construction upon them : for in general the acclivities are of short duration, and concentrated at particular points, and the engine to surmount them, to avoid expense, inconvenience, and delay, continues its route over the level parts of the road, of which there is usually a much greater amount. Thus the whole route, however level, would be necessitated to receive a superstructure commensurate with the increased weight of the engine, and the wear and tear would be proportionably greater, without any particular advantage to be derived. But in the case before us, no want of economy of that kind can arise, for we have a section of steep grades of sufficient length to justify the employment of heavier engines, and, as it were, to form a system within itself. No loss of power, no wear and tear, will exist without its corresponding advantage, and thus the economy of trade will be secured.

We propose by this, that a system of lighter grades, lighter engines, and

lighter superstructure should be adopted to the foot of the mountains, where a depot would be established. Thence during the mountain section, upon one system of heavier grades, a heavier superstructure and heavier engines should be resorted to; and on reaching the summit, after (say) 22 miles of development upon this system, a new depot will be established, and thence a system of lighter grades conformable to the character of the country.

No author has yet treated the subject of power in locomotive engines with the science and practical experiment of De Pambour. Having analyzed the machine to its ultimate limit, he has deduced with the most rigorous exactness, upon true and incontrovertible principles of mechanics, formulæ which apply to every modification of weight, speed, and degree of inclination; and the correctness of his theory is attested by a system of elaborate experiments; for we remark, that between these experiments, conducted with all the minutiae of detail, and the results obtained from his theoretical analysis, the coincidence is singularly exact.

Without entering into minutiae, which may be studied at length from the author, by those more than generally interested, we will cursorily refer to the elements that enter into the formulæ from which are derived his results. Generally divided they are—1st. The forces of resistance to the progressive motion of the engine along the rails; and 2nd. The propelling force (opposed to this resistance) resident in the elastic power of the steam. The piston may be said to be the agent between these two counteracting forces. The power opposed to the progressive motion of the engine along the rails, is composed of the resistance of the load, (per ton,) the friction of the engine separately, and the friction of the load, (per ton.) To this may be added the atmospheric resistance. The second, a counteracting power resident in the steam, involves the idea of the *evaporating power* of the engine, the *ratio of volume* of water evaporated and steam generated, and the *pressure* of steam on the boiler; whilst the action of the piston as the intermediary agent, involves a consideration of the circumference of the *wheels* of the engine, circumference of the *piston*, and *length of its stroke*.

Let F represent the friction per ton of engine, (determined by experiment.)

T “ the number of tons per ton.

a “ the additional friction of engine for every ton of load, (determined by experiment.)

Let b represent the friction per ton of load, (also determined by experiment.)

And we shall have for the absolute resistance to the progressive motion of the engine, the following expression.

$$(F + aT + bT)$$

This resistance communicated to the piston, (and denoted by R) is as follows:

Let c represent the ratio of the circum. to the diam. ($= 3.1416$)

l “ the length of stroke.

D “ the diameter of wheel.

d “ the diameter of cylinder.

Then

$$(F + aT + bT) : R :: 21 : cD$$

and

$$R = \frac{(F + aT + bT) cD}{21}$$

is the resistance on the piston.

This being divided by the area of the section of the two pistons, of which d is the diameter, we shall have for the resistance on the piston *per unit of surface*.

$$R' = \frac{(F + aT + bT) \frac{cD}{21}}{\frac{cd^2}{2}}$$

Add the resistance of the atmosphere, (denoted by p), and we have

$$R = \frac{(F' + aT + bT) \frac{cD}{21}}{\frac{cd^2}{2}} + p$$

Or,

$$R = (F + aT + bT) \frac{D}{d^2 21} + p \dots \dots \dots (a)$$

This expression involves the *absolute resistance to motion* along the rails, by virtue of the gravity of the mass and friction, as well as the *resistance communicated to the piston per unit of surface*, through the machinery, and finally the *resistance of the atmosphere* upon the piston per unit of surface. The opposing resistances are those which arise from the elastic force of the steam, and are embraced in the second division of the question above referred to.

In passing from the boiler to the cylinder, the volume of steam generated must necessarily be changed, in the inverse ratio of the respective pressures in the boiler and the cylinder. Thus if $\frac{r}{r'}$ is the ratio of the volume of steam to the volume of water, and $\frac{rs'}{rs}$ the effective evaporating power of the engine per minute, in cubic feet, $\frac{rs}{r}$ will be the volume of steam generated in a minute at a given pressure P , and $\frac{rs'P}{R}$ will be the space occupied by the steam in the cylinders: and this cubical content being divided by the area of the section of the two cylinders, gives the other element, or the speed at which the steam passes through the cylinders. This expression therefore becomes,

$$\frac{\frac{rs'P}{R}}{\frac{cd^2}{2}}$$

Denoting by v the velocity with which the steam passes through the cylinders, we have

$$v = \frac{2 rs' P}{cd^2 R} \dots \dots \dots (b)$$

Let V represent the velocity of the engine; cD being the circumference of the wheel, and l the length of stroke; then

$$V' : v :: cD : 2l$$

$$v = \frac{2lV'}{cD}$$

Substituting this value of v in equation (b)

$$\frac{2 l V'}{c D} = \frac{2 r s' P}{c d^2 R}, \text{ or}$$

$$d^2 R l V' = r s' P D$$

whence

$$R = \frac{r s' P D}{d^2 l V} \dots \dots \dots (c)$$

By comparing this equation with that found above (equation a) for the resistance of the load upon the piston, and substituting for R its value in it, we arrive at the general equation on which De Pambour has founded his calculations.

$$\frac{r s' P D}{d^2 l V} = \frac{(F + a T + b T) D}{d^2 l} + p$$

To pass from the speed per minute to the speed per hour, let $60 s' = s \dots \dots$ and $60 V' = V$, which does not alter the equation; hence the values of V and T are drawn, representing the velocity per hour, and the gravity of load, as follows:

$$V = \frac{r s P D}{(F + (a + b) T) D + p d^2 l} \dots \dots (d) \dots \text{ and}$$

$$T = \frac{r s P D - V p d^2 l}{D V (a + b)} \frac{F}{(a + b)} \dots \dots (e)$$

being the amount of load an engine is capable of drawing on a level with a given velocity. But this has its limit, which is established by the conditional equation $P = R$. As must appear obvious, that is where the resistance on the piston becomes equal to the pressure on the boiler. Beyond this, no rational results are to be derived from the formula. In equation (c) make $P = R$, and substitute the value of V drawn from that equation in equation (d), and the value of T in this last equation will determine the maximum load; that is,

$$T = \frac{(P - p) d^2 l}{D (a + b)} \frac{F}{(a + b)} \dots \dots \dots (f)$$

I have thought it excusable to go through the discussion, in order to satisfy those who may not be enabled to consult the author upon whom I have so liberally drawn. The above expression will enable me to show results which I hope will inspire confidence in the scheme of surmounting our greatest elevations by means of locomotive power.

Assuming an engine of 12 tons weight of the following dimensions as adaptable to a grade of 60 feet per mile, and working at a pressure of 70 pounds to the square inch, and a velocity of 10 miles per hour:

Diameter of cylinder	-	-	=	1.16 feet.
Diameter of wheel	-	-	=	4.5 "
Length of stroke	-	-	=	1.33 "

Evaporating power, deduced from heating surface = 53 cubic feet, and introducing these values into the formula (e) we have as the result,

$$T = \frac{360 \times 80 \times 144 \times 55 \times 4.5 - 52800 \times 1.35 \times 1.33 \times 211}{9} \quad 180$$

which reduces itself to $T = 366.4$.

The mode of estimating the relative loads than can be propelled on a level, and on a plane of given inclination, is found so generally in reports on railroads, that it will be sufficient to state the equations, and make the application to the case proposed.

If

$$\frac{T + E}{h} \times 2240$$

represent the gravity of engine and load reduced to pounds on a plane inclined in the ratio as 1 to h, and

$$T' \times F$$

the friction of load, (T' being the number of load, E the number of tons weight of engine, and F the friction per ton of load,) then the resistance upon said plane will be expressed by

$$R''' = \frac{T' + E}{h} \times 2240 + T$$

Hence,

$$T' = \frac{R'''h - E \times 2240}{bh + 2240}$$

Substituting for R''' its value $T' F$ (that is, the number of tons (T') on a level, multiplied by the friction per ton (F) we have

$$T' = \frac{T' b h - E \times 2240}{b h + 2240}$$

Now, by substituting for T' , our value for the load of which our engine has been found capable on the level, we deduce (making the weight of the engine (E) 12 tons, $b = 8$ lbs., and $h = 88$, the inclination being 60 feet to the mile)

$$T' = \frac{366.4 \times 8 \times 88 - 2240 \times 12}{8 \times 88 \times 2240} \dots = 78.4$$

Thus, for the supposed engine we have a power of traction upon the inclined plane of 60 feet per mile, equal to 78.4 tons, at a velocity of 10 miles per hour; a load per engine exceeding what would be necessary to constitute an expedient amount of intercourse upon the mountain section of the road.

The power of this engine might be increased, as well as its force of adhesion, by an increase of fire-box and heating surface, which I have assumed very far below what might have been adopted consistently with the other proportions of the engine. And the pressure upon the boiler is equally assumed much lower than necessary in order to exhibit the *full* power of the engine.

It would be useless to go into minute examination as to the exact capacity of the engine at present, as it will depend upon the system of grades adopted, which is dependent upon the route selected for the location of the road, which, of course, will be a primary consideration.

An engine projected by Mr. Henry R. Campbell, of Philadelphia, for high grades, would have the power of traction as shown in the annexed table, working at a pressure of 80 lbs. to the square inch on the boiler, and a velocity of ten miles per hour. These results are found by substi-

tuting the dimensions in the formula (f) for the maximum power and velocity of the engine.

$$V = \frac{rs D}{d^2 l},$$

deduced by making $P = R$ (the pressure equal to the resistance) in equation (c) page 4. Substituting in this value of V the numerical values of the respective quantities, we have,

$$52800 = \frac{360 \times S \times 4.5}{(1.16)^2 \times 1.3},$$

whence,

$$S = \frac{52800 \times (1.16)^2 \times 1.3}{4.5 \times 360} = 55,$$

for the effective evaporating power of the engine in cubic feet, per hour. The amount of friction, as found by exact experiment, as shown by De Pambour, is 1 lb. increased friction of engine per ton of load, and 8 lbs. per ton (that is making in our equation $a + b = 9$) resistance upon a level straight road. In order to meet the resistance, however, that may arise from curvatures, I have estimated 12 lbs. friction, and this value, that is, $a = 1.5$, and $b = 10.5$ is introduced in the equation from which the tabulated results are drawn.

Table, calculated for Mr. Henry R. Campbell's engine, showing the maximum load on grades from 10 to 130 feet per mile, with a velocity of 10 miles per hour.

Grade.	Velocity.	Maximum load.
Level,		368,04
10 feet per mile	10 miles per hour	258,600 tons.
20 " " "	" " " "	198,189 "
30 " " "	" " " "	159,799 "
40 " " "	" " " "	133,266 "
50 " " "	" " " "	113,832 "
60 " " "	" " " "	98,985 "
70 " " "	" " " "	87,573 "
80 " " "	" " " "	77,195 "
90 " " "	" " " "	70,006 "
100 " " "	" " " "	63,339 "
110 " " "	" " " "	57,803 "
120 " " "	" " " "	52,981 "
130 " " "	" " " "	48,762 "

Thus the theory fully sustains the great effects that have been exhibited by late experiments, and shows that they are neither the result of a collusion, nor of adventitious circumstances, but are such as may be ever relied on in scientific practice. The truth is, as far as experience goes, that the adhesion of the wheel on the rail is the limit of the power of the engine ;

and as the force of traction in the engine is here shown to surpass any amount of tonnage that may be required, even upon the ascent of our steepest grades, it will be necessary only to demonstrate that the adhesion will not be wanting, to effect the progressive motion of the engine along the rails, without any sliding of the wheels. And this may be done by reference to experiment only, for the circumstances of adhesion are governed very greatly by atmospheric changes and other contingencies, and therefore elude any attempt at strictly scientific investigation, or at least by reference to any definite results.

At various periods of the year 1834, experiments were made in regard to the friction of locomotive engines, under the superintendence of De Pam-bour, on the Liverpool and Manchester railroad, during the course of which engines of 8 tons in weight surmounted the Sutton inclined plane (inclination $\frac{1}{8}$) with ease, drawing loads varying from 183 to 244 tons, in 13 cars, an average weight of 200 tons. In these cases no sliding whatever took place upon the rails, and we may therefore deduce, that as the engines weighed on an average 9 tons, and regarding only $\frac{2}{3}$ of the weight as the insistant weight on the working wheels, we shall find that the least amount we can allow for adhesion, as derived from experiment, would be 33 times the insistant weight. Hence an engine with coupled wheels, weighing 8 tons and bearing with its whole mass upon the working wheels, would give an adhesion in the engine capable of drawing 264 tons, on a level. That the adhesion might have been much greater, may be supposed from a particular case. The Firey engine, of 8.20 tons, with an assistant weight of only 5.5 tons upon its driving wheels, drew a load of 244 tons, or a weight of $44\frac{1}{2}$ times greater than itself. Thus under the same circumstances, this engine, with all its weight upon the driving wheels, would have drawn 356 tons, or $44\frac{1}{2}$ times its own weight upon a level.

In experiments made upon the Lowell road with an engine designed by G. W. Whistle, and under his superintendence, a load of 388 tons, reduced to a level, was drawn by an engine weighing about 9 tons, with about 5 tons insistant weight upon the driving wheels. In this case the adhesion is found sufficient for the traction of a load of 388 tons, or about 67 times the weight from which it is derived. This, however, is not a single instance of the great results exhibited upon this road; and they unquestionably proceed from the very excellent construction of the road, by which the ordinary flexion of the rail is entirely obviated. On the Columbia railroad, an experiment has been made, of which the details are given in the American Railroad Journal, as follows. Referring to the experiment, it states:

"The length of the plane is 2,800 feet, the grade 369 feet to the mile, or a rise of 1 foot in 14.3, weight of the engine with water 14,930 lbs. Load drawn up the plane, including weight of tender with water and coal, two passenger cars and 53 passengers, equal to a weight of 31,270 lbs. or 14 tons nearly. Pressure on the boiler, less than 80 lbs. to the square inch. It is to be remembered that the rails were wet with dew, (a circumstance unfavorable to the effect.) Insistant weight upon the driving wheels 8,700 lbs., or 4 tons nearly." Now this experiment was witnessed by numbers, and the names of the passengers who ascended the plane are referred to in the publication, and under all circumstances there can be no doubt of the fact that such was the performance of the engine; and although we should

make a very considerable allowance for discrepancies, yet there remains enough to exhibit a very extraordinary result, not so much in regard to the power of the engine, as the power of adhesion therein exhibited. Reducing to a level the load of 14 tons, we shall have,

$$\begin{array}{rcl} \frac{6.5 \times 2240}{14} = 1040 \text{ lbs.} & & \text{Gravity of engine on inclined plane of 1 in 14.} \\ 7.5 \times 8 = 60 & & \text{Friction of carriages at 8 lbs. per ton.} \\ \hline \frac{7.5 \times 2240}{14} = 1200 & & \text{Gravity of 7.5 tons reduced to lbs. on inclined plane.} \\ \hline 2300 & = & \text{sum of resistances.} \end{array}$$

On a level, 8 lbs. force of traction overcomes one ton of resistance; therefore, the above sum of resistance divided by 8, will give for the number of tons on a level $\frac{2300}{8} = 287.5$ tons.

The result in regard to the power of the engine, as established by experiment, conforms so very nearly to the theory which we have discussed, that we may draw the inference that the whole statement, embracing the element of the adhesion upon the rails (of which it is at present question) is correct. In fact, if we substitute the numerical values of the different dimensions in the formula, for the maximum load on a level, we have

$$T = \frac{(P - p) d^2 l}{9D} - \frac{F}{9};$$

that is,

$$T = \frac{80 \times 144 \times 7293 \times 1.47}{9 \times 4} - \frac{112}{9}$$

or,

$$T = 326.25,$$

the power of the engine on a level; which, being reduced to a plane with an inclination of 169 feet per mile, gives for the result,

$$T' = \frac{hTb - 2240 E}{hb + 2240}$$

Substituting for T (the number of tons on a level) its value, we have

$$T' = \frac{326.25 \times 8 \times 14.3 - 2240 \times 6.5}{14.3 \times 8 + 2240}$$

whence,

$$T' = 9.66.$$

If to this we add the weight of the engine, which is 6.5 tons, we have

$$16.16 \text{ tons,}$$

which shows that 14 tons was not quite the maximum load of the engine, and that nothing has been stated in regard to the power of the engine but what is conformable to established theory. In the ninth annual report on the Baltimore and Ohio railroad, results are given, derived from experiment, which must satisfy even the skeptic as to the feasibility of the scheme in question. And, at the same time, under the direction of J. Trimble, chief engineer of the Baltimore and Susquehanna railroad, extensive

portions of railroad are being constructed with grades of 90 feet per mile for locomotive power, and the engine intended to surmount them, weighing 14 tons, is by this time completed.

I transcribe from the report of Jonathan Knight, chief engineer of the Baltimore and Ohio railroad, above referred to, a table of results, which may be fully relied upon, in which it is obvious that pains have been taken, in the data assumed, at least not to allow them to exceed the effective force of the machine.

Locomotive, $7\frac{1}{2}$ tons.					
Tender, $4\frac{1}{2}$ "					
Speed,		10	14	17	20
GRADES.	{ Level . . .	175	120	96	80
	{ 25 feet per mile	87	57	44	35
	{ 50 " " "	54	35	26	20
	{ 75 " " "	38	23	16	11
	{ 92 " " "	30	17	12	8

Locomotive, $8\frac{1}{2}$ tons.					
Tender, $5\frac{1}{2}$ "					
Speed,		10	14	17	20
GRADES.	{ Level . . .	200	136	109	90
	{ 25 feet per mile	100	66	51	41
	{ 50 " " "	63	40	30	23
	{ 75 " " "	44	27	20	15
	{ 92 " " "	36	21	15	10

Thus the friends of the project, although they have not absolutely *seen* mountains traversed by locomotive power upon railroads, have every demonstration before them that the faculty exists in the machine; and that no apprehension should exist upon their minds as to the success of the enterprise.

Our next object will be to show that, from absolute surveys, executed with care, experience, and science, we are enabled to adopt, not a system of grades of 90 feet per mile, but a route whose maximum grade is only 60 feet per mile, and that only on a very inconsiderable portion of the route.

In making up our minds to the conclusions at which we have arrived, and being impressed with the importance of any determination that might be based upon them, we have not relied entirely upon our own resources. The most able engineers of our country have been corresponded with, touching the various elements that might serve to throw light upon the subject. We are indebted for communications from Messrs. Knight, Moncure Robinson, Sylvester Welsh, and Isaac Trimble, but particularly from Mr. Whistler; whose voluminous communications have much tended to elucidate the subject, and the results of their excellent experience have been added to our own laborious investigations. From the report of Mr. Knight, we have exhibited tables of grades adapted to certain powers of the locomotive engine. Whilst Mr. Whistler, by his experiments, has furnished us with the most satisfactory data, not only in reference to this subject, but likewise in regard to the amount of adhesion in a well constructed road, which surpasses any other of which we have a knowledge.

These inquiries, we were sure, would afford great gratification to the stockholders, as serving to inspire additional confidence in regard to the opinions we announce.

Before concluding these remarks, which have already unavoidably exceeded the limits we had designed, (for we have not had time to condense,) we would say that whatever doubts there may be, or hesitancy in determining the precise location across the Alleghany mountains, and thence south

ward through the low countries —, from the fact of the several routes converging as they do at Columbia, no doubt exists in our minds, that *Columbia*, or its immediate vicinity, may be regarded as a *point*.

Respectfully submitted, by, gentlemen,

Your obedient servants,

WM. GIBBS M'NEILL, *Engineer, &c.*

W. G. WILLIAMS, *Associate Engineer.*

Gen. R. Y. HAYNE,

President of the Company.

NOTE.—We cannot, without closing this report, avoid adverting to the very satisfactory manner in which the assistants of every grade have performed their various duties. Of this, the best evidence is the work already executed, both in the field and bureau. And although the number engaged upon the service precludes the possibility of announcing them, severally, by name at this time; yet we hope their *esprit de corps* will be gratified by this unequivocal expression of our obligations to them as a body.

A.

Elevations of "gaps" referred to the "plane of reference," on the north fork of Saluda, at Col. Hodges.

Saluda gap	-	-	-	-	-	-	-	-	1,264.833
Reedy Patch gap	-	-	-	-	-	-	-	-	1,143.638
Butt mountain	-	-	-	-	-	-	-	-	1,093.500
High Tower's gap	-	-	-	-	-	-	-	-	1,296.492
Gap of old road	-	-	-	-	-	-	-	-	1,214.109
Gap Creek gap, at B. M. A IV	-	-	-	-	-	-	-	-	1,112.526
Laquey's gap, at head of Broad river and Swannano	-	-	-	-	-	-	-	-	1,949.233
B. M. A X 11 at Reedy Patch gap	-	-	-	-	-	-	-	-	1,147.309
Summit of Gap Creek gap	-	-	-	-	-	-	-	-	1,113.248
Saluda gap, above tide water, at Charleston	-	-	-	-	-	-	-	-	2,339.9
Reedy Patch gap	-	-	-	-	-	-	-	-	2,218.7
Butt Mountain gap	-	-	-	-	-	-	-	-	2,168.6
High Tower's gap	-	-	-	-	-	-	-	-	2,371.6
Gap in old Saluda road	-	-	-	-	-	-	-	-	2,289.2
Gap Creek gap, at B. M. A IV	-	-	-	-	-	-	-	-	2,187.6
Laquey's gap	-	-	-	-	-	-	-	-	3,024.3
B. M. A X 11, at Reedy Patch	-	-	-	-	-	-	-	-	2,222.4
Summit of Gap creek	-	-	-	-	-	-	-	-	2,188.3

Mr. Colcock's B. M. Laurens's ridge, near Greenville, 802 feet above Columbia.

B.

TABLE of grades on the Reedy Patch and Broad river inclined planes.

Distance.	Fall.	Total fall.	
<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	
900	Level		
4,700	163.68	145	
1,000	Level		
4,400	57.50	50	
1,400	Level		
3,800	277.88	200	
1,400	Level		
1,800	498.89	170	
1,800	Level		
4,150	150.48	124	689 feet fall to Broad river.
4,750	39.6	36	Curved line uniting Reedy Patch and Broad river planes.
500	Level		
5,600	301.68	340	
1,800	Level		
1,800	322.66	110	
700	Level	-	To foot of inclined planes, from which point the grade descends 39.6 per mile.
	Total	1,175	

TABLE of straight line and curves on Reedy Patch and Broad river line.

Straight.	Radius.	Distance.	
<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	
25,350			
	674 R	1,150	
	1,940 L	950	
700			
	1,637 R	1,650	
	400 L	300	
10,400			
	601 L	400	To foot of inclined planes.
	764 R	600	

C.

TABLE of excavation, and embankment, and masonry, on the French Broad line, from Paint creek to Newport, twenty-two miles and eight hundred and forty feet.

	Distance.	Excavation.	Embankment.	Excavation of	Rock.	Bridges.	Culverts.	Wall.	
	Miles.Ft.	Cub. yds.	Cub. yds.	Cub. yds.	Cub. yds.	Perch.	Perch.	Perch.	
1	1	7,823	71,703	63,880	-	7,105	-	-	{ 2 river bridges & 2 road bridges Quartz rock.
2	1	-	36,761	37,761	13,065	-	20	640	
3	1	9,167	18,812	9,645	-	-	126	-	
4	1	19,084	7,769	-	-	267	-	-	
5	1	2,323	23,796	21,473	-	-	149	-	{ Quartz rock. Sand stone rock.
6	1	1,672	17,185	15,513	-	-	138	-	
7	1	29,784	2,023	-	-	-	117	-	
8	1	6,030	25,566	19,536	-	-	46	-	
9	1	19,228	19,299	71	-	-	94	-	
10	1	14,364	9,973	-	-	267	19	-	
11	1	31,779	6,603	-	-	-	215	-	
12	1	3,750	14,163	10,413	-	-	40	-	
13	1	1,872	40,131	38,259	1,500	-	59	1,200	
14	1	5,181	40,047	19,163	16,703	-	112	-	
15	1	57,483	16,406	-	18,438	-	128	-	{ Lime stone rock 2 tunnels 100 and 130 feet in limestone rock
16	1	3,610	53,579	43,969	6,000	-	183	496	
17	1	88,979	18,381	-	-	-	74	-	
18	1	13,929	29,564	15,635	-	-	122	-	
19	1	66,696	15,282	-	100,634	-	12	1,152	
20	1	19,092	6,155	-	8,784	-	80	1,450	
21	1	5,605	26,693	8,382	12,200	-	75	-	
22	1 840	28,282	7,771	-	39,381	-	168	-	
		435,733	507,661	303,210	205,005	7,639	1,977	4,928	

D.

TABLE of the estimate of cost of formation of a road bed from Paint creek to Beaufort.

435,733 cubic yards of excavation, at 18 cents per yard	-	-	-	\$80,431 94
303,210 cubic yards of embankment, at 14 cents per yard	-	-	-	42,449 94
44,500 cubic yards of rock excavation, at \$1	-	-	-	44,506 00
160,499 cubic yards of rock excavation, at 75 cents	-	-	-	120,374 25
6,657 perches of masonry, for two bridges across the French Broad, at \$4	-	-	-	26,668 00
972 perches of masonry, for small bridges, at \$2½	-	-	-	2,430 00
1,977 perches of masonry, for culverts, at \$1½	-	-	-	2,965 50
4,928 perches of masonry, for side walls, at \$2	-	-	-	9,856 00
2 tunnels 230 feet long, (lime stone,) at 30 cents	-	-	-	6,900 00
Superstructure of 2 bridges, 600 feet each, at \$20	-	-	-	12,000 00
Superstructure of 2 small bridges, 15 feet span, at \$150	-	-	-	450 00
Superstructure of 1 bridge, 100 feet span, across Big creek, at \$15, 22, 16 miles	-	-	-	1,500 00
				\$350,531 09

E.

TABLE of curves on the line of Clear creek, from Reedy Patch gap to Mud creek, eight and a half miles.

Straight.	Curves.		See map of Clear creek.
<i>Feet.</i>	<i>Rad. feet.</i>	<i>Dist. feet.</i>	
1	1,432 R	1,200	
5,500	2,865 R	1,000	
3,000	2,865 L	600	
5,000	2,865 L	2,100	
2,800	2,865 R	1,100	
2,040	2,865 R	300	
1,020	1,910 L	700	
400	1,910 L	800	
	1,910 R	1,000	
	1,910 L	1,200	
2,400	3,820 R	1,600	
	5,730 R	1,800	
2,200	1,910 L	1,000	
2,000	2,865 R	1,600	
600	1,910 R	800	
	1,432 R	800	

F.

TABLE of grades, on Clear creek line, from Reedy Patch gap to Mud creek.

Distance feet.	Fall per mile.	Total fall.	See profile of Clear creek line.
	<i>Feet.</i>	<i>Feet.</i>	
1,300	Level		
9,200	52.04	92.000	
19,200	90.08	33.024	
6,000	14.09	16.020	
7,800	6.17	8.970	
8½ miles.	17.65	150.014	

F—Continued.

ESTIMATE of excavation, and embankment, and masonry, on Clear creek line, from Ready Patch gap to Mud creek.

Section 1.	70,922 cubic yards excavation, hard gravel, average level 3,000 feet, at 25 cents	\$17,724 50
	27,293 cubic yards embankment, loose earth, average level 300 feet, at 15 cents	4,093 95
Section 2.	42,051 cubic yards excavation, level gravel, average level 500 feet, at 18 cents	7,569 18
	106,180 cubic yards embankment, loose earth, average level 50 feet, at 12 cents	12,741 60
	4,500 cubic yards rock excavation, gneiss and mica slate, at \$1 25	5,625 00
Sec. 1 and 2.	533 perches of culverts, at \$1 50	799 50
	2,353 perches in 13 bridges across Clear creek, at \$3	7,059 00
	Frame work for 13 bridges, 30 feet long each, 390 feet, at \$10	3,900 00
		\$57,512 73

G.

TABLE of excavation and embankment on Mud creek and French Broad line, from Butt Mountain gap to bench mark B. 1, below Asheville.

	Distance.	Excavation.	Embankment.	Excavation of embankment.	Excavation of rock.	Bridges.	Culverts.	Walling.
	<i>Feet.</i>	<i>Cub. yds.</i>	<i>Cub. yds.</i>	<i>Cub. yds.</i>	<i>Cub. yds.</i>	<i>Perches.</i>	<i>Perches.</i>	
1	4,000	17,617	12,810	-	-	-	100	
2	6,400	18,130	19,254	1,124	-	-	36	
3	6,000	27,583	27,146	-	-	-	128	
4	6,000	45,287	35,560	-	-	-	84	
5	4,400	29,410	28,097	-	-	-	133	
6	8,000	48,913	86,733	37,820	-	1,320	101	
7	6,200	53,560	28,043	-	1,500	-	137	
8	6,600	17,338	55,190	37,802	-	-	62	
9	6,400	41,298	51,952	10,654	-	970	177	
10	5,200	5,174	107,382	102,208	-	-	177	
11	10,400	12,180	111,730	99,550	-	-	117	
12	8,500	16,503	42,316	25,813	-	970	110	
13	8,200	1,313	28,294	26,981	-	-	155	
14	9,600	9,033	23,421	19,378	-	-	68	
15	8,600	8,855	54,325	45,470	3,000	-	268	
16	9,400	12,002	9,824	-	8,000	-	125	
17	10,200	20,052	29,353	9,301	3,000	-	156	
18	9,800	14,559	18,052	3,493	6,000	-	197	
19	8,000	14,233	19,575	5,342	-	-	213	
20	8,000	8,006	38,695	30,589	-	-	81	
21	10,000	22,017	55,573	33,556	-	-	107	
22	10,000	5,961	42,305	36,344	-	970	181	
23	8,000	4,854	9,217	4,393	-	-	100	
24	10,000	2,955	23,537	20,562	-	-	130	
25	10,000	5,693	6,524	831	-	-	136	
	37½ miles	462,570	968,938	561,231	21,500	4,230	3,309	

H.

ESTIMATE of cost of construction of road bed, from Butt Mountain gap to five miles below Asheville.

462,570 cubic yards of excavation, level gravel, average level 1,500 feet, at 20 cts.	\$92,514 00
561,231 cubic yards of embankment, loose earth, average level 100 feet, at 14 cts.	78,572 34
21,500 cubic yards rock excavation, gneiss and mica slate, at \$1 25	26,875 00
4,230 perches dry masonry, for abutments of bridges, at \$3	12,690 00
3,309 perches dry masonry, for culverts, at \$1 50	4,963 50
4 bridges, 100 feet each, \$15 per foot	6,000 00
1 bridge, 12 feet	100 00
Thirty-seven and a half miles	\$221,615 34
\$5,909 73 per mile.	

I.

TABLE of the line from Butt Mountain gap to bench mark B. 1, on the French Broad, four and three fourth miles below Asheville.

Straight.		Curves.		Straight.		Curves.	
Distance feet.	Radius feet.	Distance feet.	Distance feet.	Distance feet.	Radius feet.	Distance feet.	Distance feet.
3,007					2,000 L	1,291	
4,900	+5,730 L	3,000		2,250	3,000 R	968	
4,900	+5,730 L	2,900			3,500 L	5,741	
3,775	+2,865 R	975			1,500 L	711	
350	+5,730 L	1,300			1,000 R	1,396	
2,500	+2,865 L	1,700		1,510	4,000 R	1,850	
2,000	+1,910 R	600			3,000 L	890	
2,000	+1,910 R	2,500			1,000 R	960	
2,100	+1,910 R	1,400		1,760	3,000 R	2,617	
200	+1,432 L	1,400			3,400 L	711	
1,200	+1,432 R	1,600			3,400 R	2,293	
16,600	+1,910 R	1,200			3,400 L	1,976	
+1,050	+1,910 L	1,600			2,800 L	1,563	
200	+1,901 L	650			5,730 R	2,449	
7,900	+2,865 L	1,775		2,300	2,800 L	1,563	
1,200	+1,432 R	2,000		7,950	5,000 L	4,275	
16,600	+1,432 L	650		1,880	1,800 R	4,794	
+1,050				3,260	1,300 R	706	
200				6,550	8,000 L	1,203	
7,900				600	800 L	*1,256	
	4,000 L	4,328			4,000 L	514	
	+1,000 R	2,479			3,000 R	2,560	
	+1,500 L	1,606			4,300 L	4,652	
2,100	1,800 R	2,827			2,300 L	3,491	
	7,000 L	2,280			2,700 R	2,067	
	1,800 L	2,795		750	1,500 R	2,279	
3,520	3,000 R	733			9,530 R	400	
1,800	3,500 R	1,221		93,005	600	985	
					-	99,672	

* At Swannano river.

The curves marked † were actually located: the others were drawn on the plan, and will not differ materially in profile from the experimental line which was run.

† To French Broad river.

K.

TABLE of grades from Butt Mountain gap to bench mark B. 1, on the French Broad, $4\frac{3}{4}$ miles below Asheville.

Distance.	Fall per mile.	Total fall.	(See map of Mud creek and French Broad.)
<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	
8,600	30.7	50,009	From the foot of Butt mountain plane to the French Broad on Posey's farm, is 11 miles and 820 feet; the total fall is 39 feet, the average fall per mile is 3.5 feet. From that point on Posey's farm to bench mark B. 1, is 80 feet less than $24\frac{1}{4}$ miles; the total fall in that distance is 127 feet, the average fall per mile is 51 feet.
13,400	7.07	17,956	
16,800	Level		
17,200	2.45	7,998	
8,000	7.27	11,000	
14,300	1.98	5,362	
13,800	2.48	6,486	
9,200	4.59	7,914	
8,800	11.40	19,098	
9,400	3.33	5,969	
8,600	7.97	12,986	
10,000	1.58	3,000	
8,000	3.30	5,000	
10,000	1.45	2,850	
8,000	4.62	7,000	
6,000	7.92	9,000	
16,000	5.81	17,600	
12,000	12.14	27,600	
198,100	5.782	216,828	
37 $\frac{1}{4}$ miles.			

L.

TABLE of the line from Paint creek, down the French Broad, to Newport.

Straight.			Curves.		
<i>Distance feet.</i>	<i>Radius feet.</i>	<i>Distance feet.</i>	<i>Distance feet.</i>	<i>Radius feet.</i>	<i>Distance feet.</i>
600	2,865 L	1,120	6,000	2,400 R	2,638
	636 L	759		1,432 L	2,211
	955 L	950	1,600	1,432 L	1,499
*660	601 R	472	1,860	1,637 R	1,914
	601 L	304	440	1,637 R	1,371
*900	818 R	1,629		5,730 R	3,900
	601 R	493		2,865 L	1,916
	5,730 L	4,140	3,400	2,865 R	1,400
	1,910 L	1,446			
1,340	601 L	461	600		
	3,820	3,633			

The letters R and L designate the curvature to right and left.
 * Across French Broad river.

TABLE L—Continued.

Straight.			Curves.		
<i>Distance feet.</i>	<i>Radius feet.</i>	<i>Distance feet.</i>	<i>Distance feet.</i>	<i>Radius feet.</i>	<i>Distance feet.</i>
200	2,865 R	1,400	2,850	3,820	1,188
800	2,865 R	800	1,000	2,865 R	800
600	2,865 R	2,300	3,480	2,865 L	800
600	1,910 R	2,250	2,000	2,865 L	1,400
4,760	1,910 R	1,037		2,865 R	600
	2,865 L	3,010		1,432 R	2,800
1,800				636 R	533
	1,700 L	1,365	1,200	1,432 L	620
	3,820 L	1,566		5,730 L	1,600
	1,700 L	417		1,910 L	267
	1,700 R	417	2,540	1,432 L	920
	600 R	241		5,730 R	1,400
1,320	2,865 R	975		3,820 R	833
1,600	1,910	966	1,200	1,432 L	2,973
1,140	2,290 L	819		1,432 R	550
	840 R	688		3,820 R	1,766
	840 L	205		1,432 L	350
				3,820 R	1,967

M.

TABLE of grades on French Broad, from Paint creek, at the North Carolina and Tennessee line, to Newport.

Distance.	Fall per mile.	Total fall	The distance from Paint creek to bench mark M. 14, half a mile above Newport bridge, is 22 miles and 840 feet. The total fall in that distance is 203 feet. The average fall per mile for that distance is 9.16 feet.
<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	
4,800	8.79	8	
9,200	25.82	45	
6,200	Level		
11,200	18.48	39	
4,000	Level		
14,000	9.24	24	
12,000	2.77	7	
600	13.2	15	
200	Level		
7,400	14.26	20	
8,600	12.27	20	
3,600	Level		
14,400	9.16	25	
13,600	Level		
11,700	9.16	203	
22 miles and 840 feet.			

N.

TABLE of curves on Mr. Drayton's line of survey down French Broad, from head of shoals, six miles below Asheville, to Paint creek, at the Tennessee line.

Radius.	Angles.	Arcs.	Tangents.	Radius.	Angles.	Arcs.	Tangents.
<i>Feet.</i>	<i>Deg. min.</i>			<i>Feet.</i>	<i>Deg. min.</i>		
2,400	7 00		1,350	1,500	13 15		1,270
800	37 30		1,050	1,500	9 45		
2,100	13 15			2,400	26 00		1,170
1,100	71 00		1,270	800	29 30		
1,000	44 30		2,870	800	35 00		
1,710	32 20			800	128 00		217
2,300	26 20			1,500	24 10		360
1,500	69 30			900	23 20		
6,240	16 10			1,600	18 45		870
800	28 30			900	22 15		
1,970	23 40			900	18 30		1,000
2,700	8 15			1,000	52 45		1,220
900	74 00		935	1,900	29 00		
2,525	35 35			2,700	20 00		
800	7 30			1,200	37 15		1,565
2,020	40 45			2,200	14 45		
990	24 00			3,800	9 45		
1,400	25 15			2,000	32 50		620
2,750	19 15		1,140	850	142 00		
2,100	34 30		1,405	1,000	27 00		
1,000	32 45		940	1,000	21 30		970
1,400	70 30		488	1,000	15 17		
2,000	11 10			1,000	26 00		
900	39 45			2,000	12 30		3,130
1,300	45 30			1,000	17 30		540
1,200	34 30			1,000	32 45		
1,200	16 00			800	67 00		
2,650	44 30			2,500	38 35		1,065
2,800	17 50			1,500	34 15		
2,200	15 30			1,500	58 30		1,350
1,200	24 00			800	72 15		685
2,100	15 20			1,000	59 15		1,113
3,000	5 30			1,600	12 15		410
4,990	54 30			800	94 00		940
1,900	9 45			1,500	14 45		2,820
2,400	31 15		460	1,000	72 45		
1,300	75 15		460	2,500	33 50		
850	6 50						
7,200	28 20						
1,500	6 00						
800	13 00						
1,100	11 00						
2,500	5 30						
2,500							

TABLE N—Continued.

Radius.	Angles.	Arcs.	Tangents.	Radius.	Angles.	Arcs.	Tangents.
<i>Feet.</i>	<i>Deg. min.</i>			<i>Feet.</i>	<i>Deg. min.</i>		
800	97 30			1,800	22 50		
1,600	37 30			1,800	29 45		
1,100	42 15			1,500	26 50		
2,000	30 10			1,500	67 50		
			660	750	182 45		
1,500	36 30			3,000	41 45		
1,900	30 30			1,500	25 30		700
1,200	18 00						
800	53 15			4,500	7 15		
1,000	19 45			2,500	26 25		
800	35 15			2,500	35 00		
			660	800	67 00		1,235
1,600	61 55						895
2,000	21 30		800	2,500	39 20		
1,800	36 30			800	49 00		
1,000	34 20			1,000	31 30		
800	41 15			800	64 00		
			300	1,500	36 15		
800	80 15			1,500	25 15		
1,400	20 15						3,425
1,000	45 00			1,500	60 00		
2,500	46 10						1,800
2,000	31 25			1,500	59 00		
			1,760	1,500	24 50		
1,000	35 15			1,500	20 10		
2,000	14 15						6,370
			1,120	2,000	34 10		
2,000	60 00			2,000	35 00		
			780	1,500	113 30		
1,000	57 30			1,200	33 50		
			990				955
2,500	22 30			1,200	66 15		
2,500	48 00						955
			1,730	1,500	33 30		
600	108 20						1,650
			2,125	1,500	85 25		
1,000	34 20		1,330	1,200	53 30		
1,000	21 30						2,340
			835	1,500	21 00		
800	38 00						765
			955	1,200	24 30		
1,500	11 00						480
1,000	19 00						

O.

TABLE of grades on French Broad river, from B. M. F. No. 1, on west side of river, opposite B. M. B. No. 1, of 1836, to station 1,060, near B. M. M. 1, of Mr. Green's line, on North Carolina and Tennessee boundary line.

Station.	Distance.	Fall per mile.	Total fall.	Remarks.
	<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>	
135	3.000	20.000	60.000	Total distance from B. M. F. 1, to B. M. M. 1, = 38.546.
	0.662	25.400	16.815	
	2.338	30.000	70.140	
331	2.488	14.085	35.045	Total fall = 662.827.
	1.512	11.243	17.000	
416	2.697	9.000	24.273	Average fall per mile = 17.196.
443	1.143	19.883	22.727	
538	3.555	13.221	47.000	
590	1.311	22.883	30.000	
705	4.021	14.922	60.000	
748	1.084	6.458	7.000	
797	1.378	16.691	23.000	
828	1.986	23.589	46.847	
875	1.914	30.000	57.420	
903	1.316	18.794	24.733	
916	0.576	30.000	17.280	
937	0.672	18.928	12.720	
971	1.713	21.016	36.000	
1,000	1.873	6.941	13.000	
1,020	1.337	17.203	23.000	
1,045	1.451	5.767	8.369	
1,060	0.517	20.228	10.458	
Total	38.544	396.252	662.827	

P.

TABULAR STATEMENT of grades run on the upper route of Green river valley surveyed by W. J. Lewis, assistant engineer Louisville, Cincinnati, and Charleston railroad, estimated from B. M. Bull Mountain gap.

Distance.	Rise.	Fall.	Grade.	CURVED LINE, (Radii of)						Straight line.	Excavation.	Embankment.	Soil.	Bridges.	Culverts.	Tunnel.	Cross drains.	Dry wall.
				3,781.	1,895.	1,260.	945.	756.	630.	5.								
1st mile section -	Feet	Feet	Feet															
2d mile -	-	49	60	330	-	-	726	-	-	-	4,972.0	39,169	Loam & sand	532	437	-	-	2,000
3d mile -	-	4	60	990	-	-	198	-	-	825	3,610.0	125,265	"	-	1,870	-	-	-
4th mile -	-	60	60	924	264	-	742	831	652	1,188	2,881.0	31,308	A little rock	300	560	-	-	-
5th mile -	-	60	60	-	-	-	1,702	-	231	-	1,822.0	78,873	Sand & rock	300	1,320	-	-	-
6th mile -	-	-	-	-	-	-	2,784	-	-	-	3,221.0	61,020	"	100	-	-	-	-
7th 4,852 feet -	-	-	-	701	-	-	-	-	-	-	1,773.4	41,564	Sand	400	-	-	-	-
8th mile & 411 ft -	-	-	lev ^l	726	-	-	-	-	853	-	2,858.0	162,456	A little rock	200	-	-	-	-
9th 4,993 feet -	-	-	-	577	-	-	847	-	1,708	-	2,547.5	137,052	"	400	-	-	-	-
10th 4,242 feet -	-	46	60	802	-	-	2,133	-	478	-	1,600.0	98,154	Sand	-	-	-	-	-
11th 5,057 feet -	-	57	60	759	539	-	-	-	654	-	1,848.0	96,730	"	-	-	-	-	-
12th 5,141 feet -	-	58	60	578	-	-	526	-	1,072	-	2,785.2	116,971	Loose rock-	176	-	-	-	-
13th 5,009 feet -	-	-	60	1,930	-	-	-	-	1,108	-	2,180.0	155,638	Rock & sand	320	-	-	-	-
14th mile -	-	-	60	1,274	-	-	1,159	-	2,812	-	1,056.0	176,538	"	600	-	-	-	-
15th mile -	-	60	60	1,277	-	1,023	198	-	1,295	-	1,452.0	204,933	"	200	-	438	-	-
16th mile -	-	60	60	-	1,122	-	-	-	924	-	3,197.0	135,831	"	520	-	-	1,020	1,248
17th mile -	-	60	60	-	-	-	858	-	1,210	-	3,246.0	155,253	"	300	-	-	768	-
18th mile -	-	60	60	627	-	-	194	-	1,551	-	2,508.0	134,189	"	300	692	430	750	5,202
19th mile -	-	60	60	1,386	528	-	330	-	1,254	-	1,782.0	71,584	"	300	830	200	500	768
20th mile -	-	60	60	-	-	-	-	-	2,409	-	2,821.0	152,958	"	600	-	-	300	-
21st mile -	-	60	60	-	-	-	284	-	4,021	-	1,320.0	143,417	"	464	-	264	750	-
22d mile -	-	60	60	-	-	-	-	-	2,413	-	2,471.0	91,910	"	1,440	-	528	530	-
23d 1,122 feet -	-	72	60	-	-	-	-	-	2,774	-	2,565.0	59,324	Sand	-	-	-	1,000	-
23d 1,122 feet -	-	-	60	-	-	-	-	-	1,585	-	4,640.0	79,268	Sand	-	-	-	1,300	-
	7,121			7,235	1,819	12,077	831	29,200	2,013	59,170.1								

Q.

TABULAR STATEMENT of the grades, &c. &c. on the mountain section of line from Gap Creek gap, &c., surveyed by R. W. Colcock, assistant engineer.

Distance.	Rise.	Fall.	Grade per mile.	RADI OF CURVES.					Tangents.	Excavation.	Embankment.	Soil.	Bridges.	Culverts.	Tunnels.
				1,032.	955.	818.	716.	636.	603.						
1st mile -	Feet 60	Feet 60	60	200	400	-	2,200	-	2,480	Cubic yards. 151,799.33	Cubic yards. 109,086.59	Coarse gravel, with sand and rock.	1 of 200 feet span	Per 540	1 of 500 feet.
2d mile -	20	20	20	-	-	-	-	-	1,580	182,328.19	80,911.79		"	810	1 of 400 feet.
3d mile -	70	70	70	-	-	-	700	-	1,980	242,439.00	140,297.00	Coarse gravel, with sand and rock.	1 of 300	270	
4th mile -	70	70	70	-	-	-	400	-	1,500	2,380	116,812.07		"	630	
5th mile -	50	50	50	-	-	200	-	-	2,500	302,935.00	92,723.00	Coarse gravel, with sand and rock.	1 of 200	540	
6th mile -	40	40	40	-	-	-	-	-	3,300	117,851.00	162,389.00		"	630	
7th mile -	70	70	70	-	-	800	-	-	2,900	127,713.00	49,863.00	Coarse gravel, with sand and rock.	1 of 100	600	
8th mile -	70	70	70	-	-	-	-	-	3,400	1,880	210,847.00		"	180	
9th mile -	60	60	60	-	-	-	-	-	3,000	44,507.00	158,918.00	Coarse gravel, with sand and rock.	1 of 200	450	
10th mile -	60	60	60	-	-	-	-	-	2,800	219,467.00	109,507.00		"	540	1 of 500 feet.
11th mile, 4,000 feet	16,969	16,969	70	-	-	-	-	-	2,680	240,979.00	120,765.00	Coarse gravel, with sand and rock.	1 of 200	500	
12th mile, 1,280 feet	53,031	53,031	70	-	-	-	-	-	-	225,376.00	110,349.00		"	540	
13th mile, 4,000 feet	2,181	2,181	90	-	-	-	-	-	-	250,769.00	175,670.00	Coarse gravel, with sand and rock.	1 of 300	630	
14th mile -	90	90	90	-	-	-	-	-	-	175,983.00	209,345.00		"	360	
15th mile -	90	90	90	-	-	-	-	-	-	198,763.00	195,854.00	Coarse gravel, with sand and rock.	1 of 200	270	
16th mile -	60	60	60	-	-	-	-	-	-	225,804.00	176,923.00		"	720	
17th mile -	60	60	60	-	-	-	-	-	-	150,796.00	204,784.00	Coarse gravel, with sand and rock.	"	630	
18th mile -	60	60	60	-	-	-	-	-	-	173,328.00	191,076.00		"	450	
19th mile -	60	60	60	-	-	-	-	-	-	145,397.00	75,832.00	Coarse gravel, with sand and rock.	"	200	
20th mile -	60	60	60	-	-	-	-	-	-	-	-		"	120	

TABULAR STATEMENT of the lower route of Green river valley, surveyed by

Distance.	Fall.	Grades.	RADI OF CURVED												
			600 to 625.	625 to 650.	650 to 675.	675 to 700.	700 to 725.	725 to 750.	750 to 800.	800 to 850.	850 to 900.	900 to 950.	950 to 1000.	1000 to 1100.	1100 to 1200.
<i>Mile.</i>	<i>Feet</i>	<i>Feet.</i>													
1st -	125	20 and 130	-	-	-	-	-	-	-	-	-	-	-	600	300
2d -	102	60 and 130	1,850	-	-	-	-	-	-	-	-	-	-	-	-
3d -	77	60 and 130	1,850	400	-	-	-	-	-	200	-	-	200	-	-
4th -	50	26 and 60	1,600	-	-	-	-	100	-	200	600	500	400	50	-
5th -	58	48 and 60	3,200	150	-	500	-	-	-	200	-	-	-	-	-
6th -	31	Lev. 48 & 60	2,390	-	-	-	-	-	600	-	300	-	200	600	-
7th -	4	Lev. and 60	4,530	-	-	-	-	-	-	-	-	200	-	-	-
8th -	-	Level -	4,445	-	-	-	-	-	-	-	-	200	-	-	-
9th -	49	Lev. and 58	3,955	-	-	-	-	-	-	-	-	-	-	-	-
10th -	58	58 -	4,280	-	-	-	-	-	-	-	-	750	-	-	-
11th -	58	58 -	4,580	-	-	-	-	-	-	-	-	400	-	-	-
12th -	39	25, 58, & 60	3,050	-	-	-	-	-	-	-	625	-	-	-	425
13th -	60	60 -	2,900	-	-	-	-	-	-	-	-	450	-	-	-
14th -	32	18 and 60	3,465	-	-	-	-	-	-	-	-	-	-	-	-
15th -	46	25 and 60	2,670	-	-	-	-	-	-	-	-	-	-	200	-
16th -	60	60 -	4,100	-	-	-	-	-	-	-	-	-	-	-	-
17th -	6	Lev. and 60	4,015	-	-	-	-	-	-	-	-	-	-	-	-
18th -	-	Level -	4,175	-	-	-	-	-	-	-	-	-	-	-	-
& 3-50	-	-	-	-	-	-	1,100	-	-	-	-	-	-	-	-
	855		57,055	505	-	500	1,100	100	600	600	1,425	3,100	800	1,450	725

R.

Edward B. White, assistant engineer Louisville, Cincinnati, and Charleston railroad.

LINE.								Tangents.	Excavation.	Embankment.	* Soil.	Bridges.	Culverts.	Tunnels.	Cross drains.	Dry wall.
1200 to 1500.	1500 to 1800.	1800 to 2100.	2100 to 2500.	4,000.	5,280.	8,000.	10,000.									
									<i>Cub. yds.</i>	<i>Cu. yds.</i>		<i>R. ft.</i>	<i>Per.</i>	<i>Run'g ft.</i>	<i>R. ft.</i>	<i>Perch.</i>
400	620	1,160	-	525	-	670	-	815	60,071	26,117	-	250	-	-	152	-
500	500	1,300	100	-	-	-	-	900	67,251	5,427	-	600	-	-	120	1,286
200	600	1,150	-	-	-	-	-	650	40,931	28,137	-	350	-	-	139	-
300	400	-	350	-	100	-	-	800	25,243	13,615	-	320	-	-	180	2,113
200	-	-	-	-	-	-	-	350	54,066	15,837	-	760	-	-	139	-
400	-	-	-	-	-	-	-	840	4,690	12,752	-	650	-	-	103	-
-	260	-	-	-	-	-	-	440	56,283	21,071	-	350	397	630	187	3,640
470	700	-	-	-	-	-	-	250	83,224	38,167	-	250	268	615 & 330	534	3,080
-	-	-	-	-	-	-	-	-	87,906	42,572	-	550	601	-	490	1,367
-	-	-	-	-	-	-	-	-	50,850	48,917	-	-	-	-	490	2,286
-	-	-	-	-	-	-	-	-	41,001	44,508	-	-	-	-	610	4,746
880	-	-	-	-	-	-	-	-	84,384	66,084	-	520	1,229	785 & 180	97	1,376
1,020	-	675	-	-	-	-	-	-	26,284	26,734	-	-	-	-	582	5,314
590	-	870	-	-	-	-	-	455	59,239	61,964	-	600	301	450	170	2,824
680	560	-	-	-	-	-	-	780	67,289	63,872	-	-	-	-	679	-
420	-	-	-	-	-	-	-	530	78,163	83,018	-	600	-	-	540	799
675	-	-	-	-	-	-	-	-	147,174	77,379	-	-	384	-	361	-
-	-	-	-	-	-	-	-	-	38,442	42,557	-	-	214	-	450	-
6,835	3,640	5,155	450	525	100	670	-	6,860	1,072,491	721,728	-	5,800	3,394	2,990	6,026	28,831

* The soil averages from eight to twenty feet in depth, lying on rock, and is hard clay, mixed with mica, except on the flats, which are alluvial. The deep cuts are estimated at one-half solid rock.